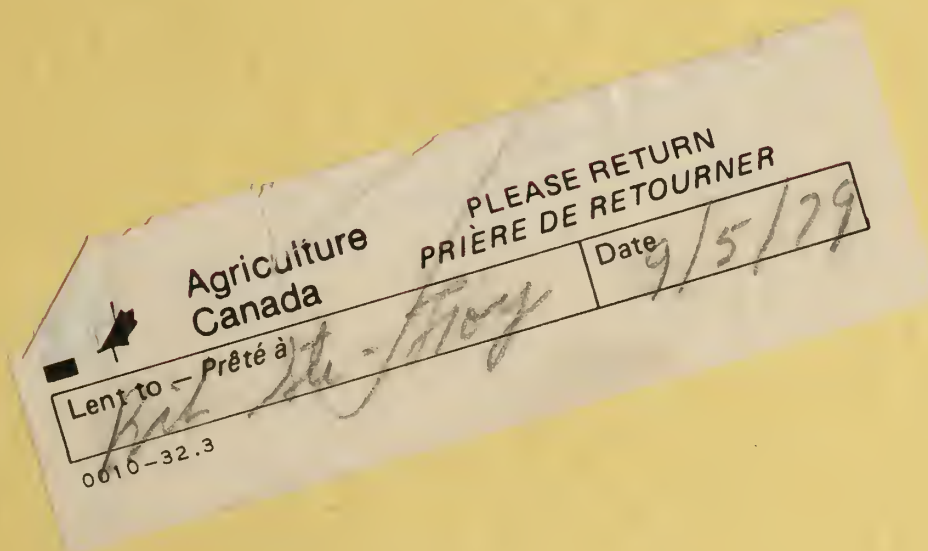


LIBRARY
CANADA AGRICULTURE
OTTAWA, CANADA

RESEARCH BRANCH REPORT

❧ 1973 ❧



630.7
C212
CANADA
Research
Br.
R 1973
c.3



Agriculture
Canada



Digitized by the Internet Archive
in 2013

Research Branch Report

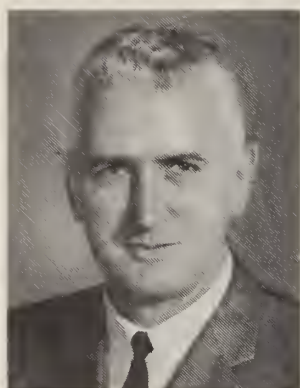
1973

CONTENTS

Executive of the Research Branch, v	<i>Direction de la recherche, v</i>
Organization Chart, vi	<i>Organigramme, vi</i>
Map of Canada, vii	<i>Carte du Canada, vii</i>
Research Coordinators, viii	<i>Coordonnateurs des recherches, viii</i>
Administration and Executive Program, ix	<i>Administration et Programmes, exécutif, ix</i>
Foreword, x	<i>Avant-propos, xi</i>
Research Stations (Eastern) <i>Stations de recherches (Est)</i>	
St. John's West, Nfld., 1	
\ Charlottetown, P.E.I., 7	
Kentville, N.S. 17	
\ Fredericton, N.B., 31	
L'Assomption, Qué., 41	
\ Lennoxville, Qué., 45	
Sainte-Foy, Qué., 53	
Saint-Jean, Qué., 65	
Delhi, Ont., 75	
Harrow, Ont., 81	
Ottawa, Ont., 93	
Vineland Station, Ont., 109	
Research Institutes and Services <i>Instituts et Services de recherches</i>	
Animal Research Institute, 117	
Biosystematics Research Institute, 129	
Chemistry and Biology Research Institute, 147	
Food Research Institute, 161	
Soil Research Institute, 171	
Research Institute, London, 183	
Engineering Research Service, 191	
Ornamentals Research Service, 199	
Statistical Research Service, 203	
Research Stations (Western) <i>Stations de recherches (Ouest)</i>	
Brandon, Man., 207	
Morden, Man., 215	
Winnipeg, Man., 223	
Melfort, Sask., 235	
Regina, Sask., 243	
Saskatoon, Sask., 251	
Swift Current, Sask., 265	
Beaverlodge, Alta., 277	
Lacombe, Alta., 285	
\ Lethbridge, Alta., 293	
Agassiz, B.C., 313	
Kamloops, B.C., 319	
Sidney, B.C., 325	
Summerland, B.C., 329	
Vancouver, B.C., 341	
Index of Professional Staff and Visiting Scientists, 351	<i>Cadres professionnels et chercheurs invités, 351</i>
Subject Index, 361	<i>Table des matières, 361</i>



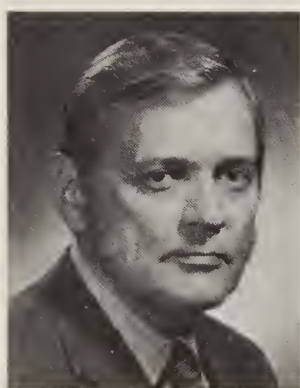
Dr. B.B. Migicovsky



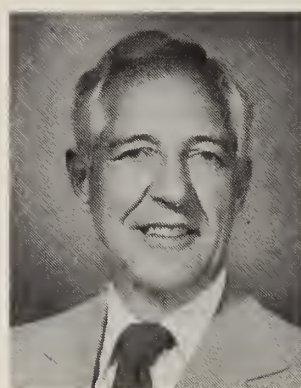
Dr. E.J. LeRoux



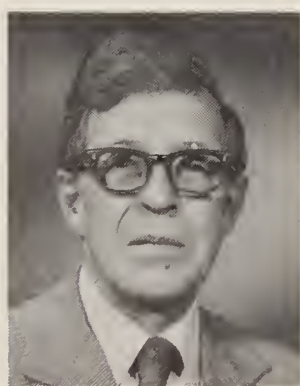
Dr. D.G. Hamilton



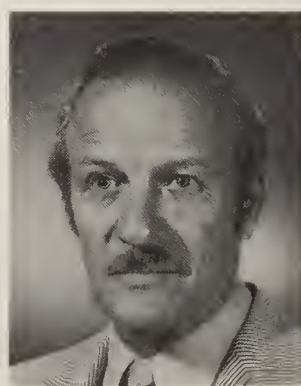
Dr. W.B. Mountain



Dr. T.H. Anstey



Dr. R.A. Ludwig



Mr. D.G. Peterson

EXECUTIVE OF THE RESEARCH BRANCH
DIRECTION DE LA RECHERCHE

Director general
Directeur général

B. B. MIGICOVSKY, B.S.A., M.S., Ph.D., D.Sc., F.C.I.C., F.A.I.C.

Assistant Director General (Planning and Coordination)
Directeur général adjoint (Planification et coordination)

E. J. LEROUX, B.A., M.Sc., Ph.D.

Assistant Director General (Eastern)
Directeur général adjoint (Est)

D. G. HAMILTON, B.Sc., M.Sc., Ph.D., F.A.A.A.S.

Assistant Director General (Research Institutes and Services)
Directeur général adjoint (Instituts et Services de recherches)

W. B. MOUNTAIN, B.Sc., Ph.D.

Assistant Director General (Western)
Directeur général adjoint (Ouest)

T. H. ANSTEY, B.S.A., M.S.A., Ph.D.

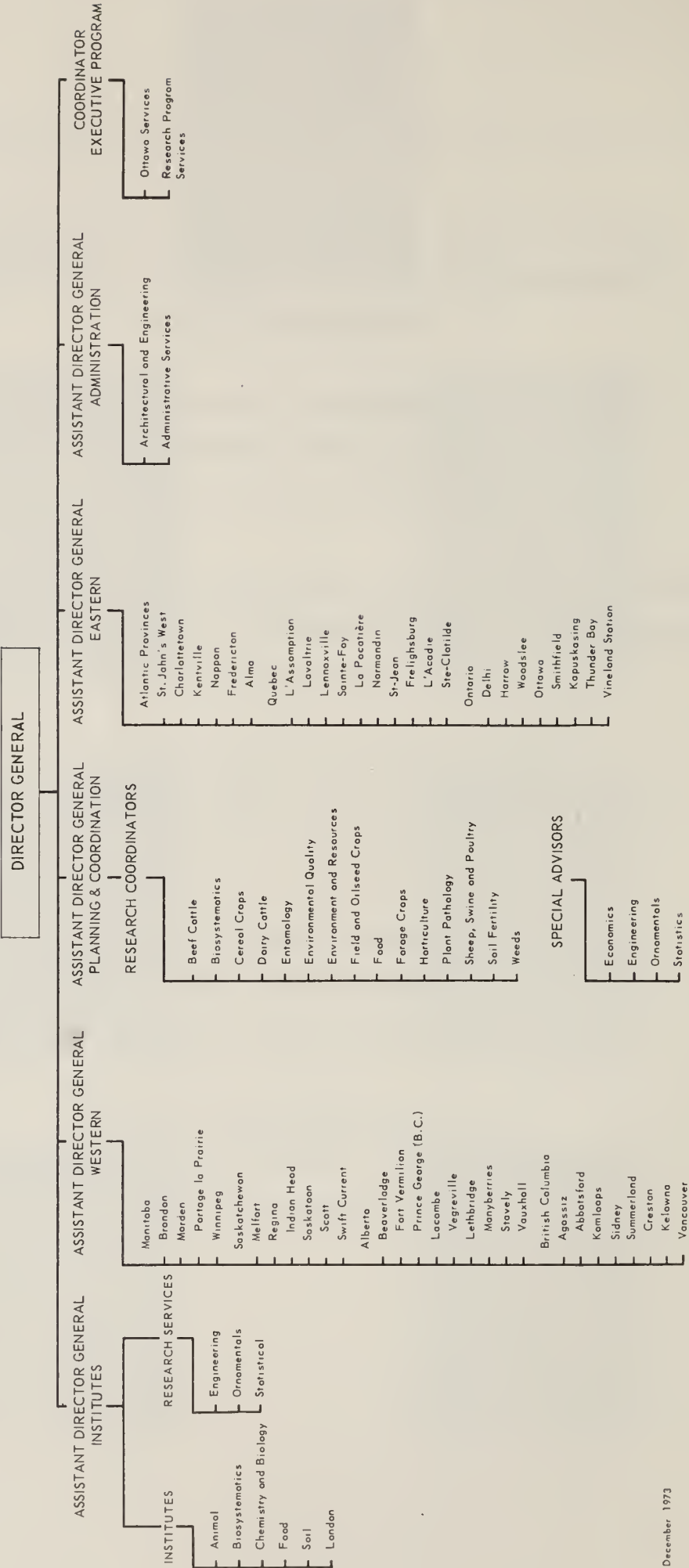
Assistant Director General (Administration)
Directeur général adjoint (Administration)

R. A. LUDWIG, B.Sc., M.Sc., Ph.D., F.A.P.S.

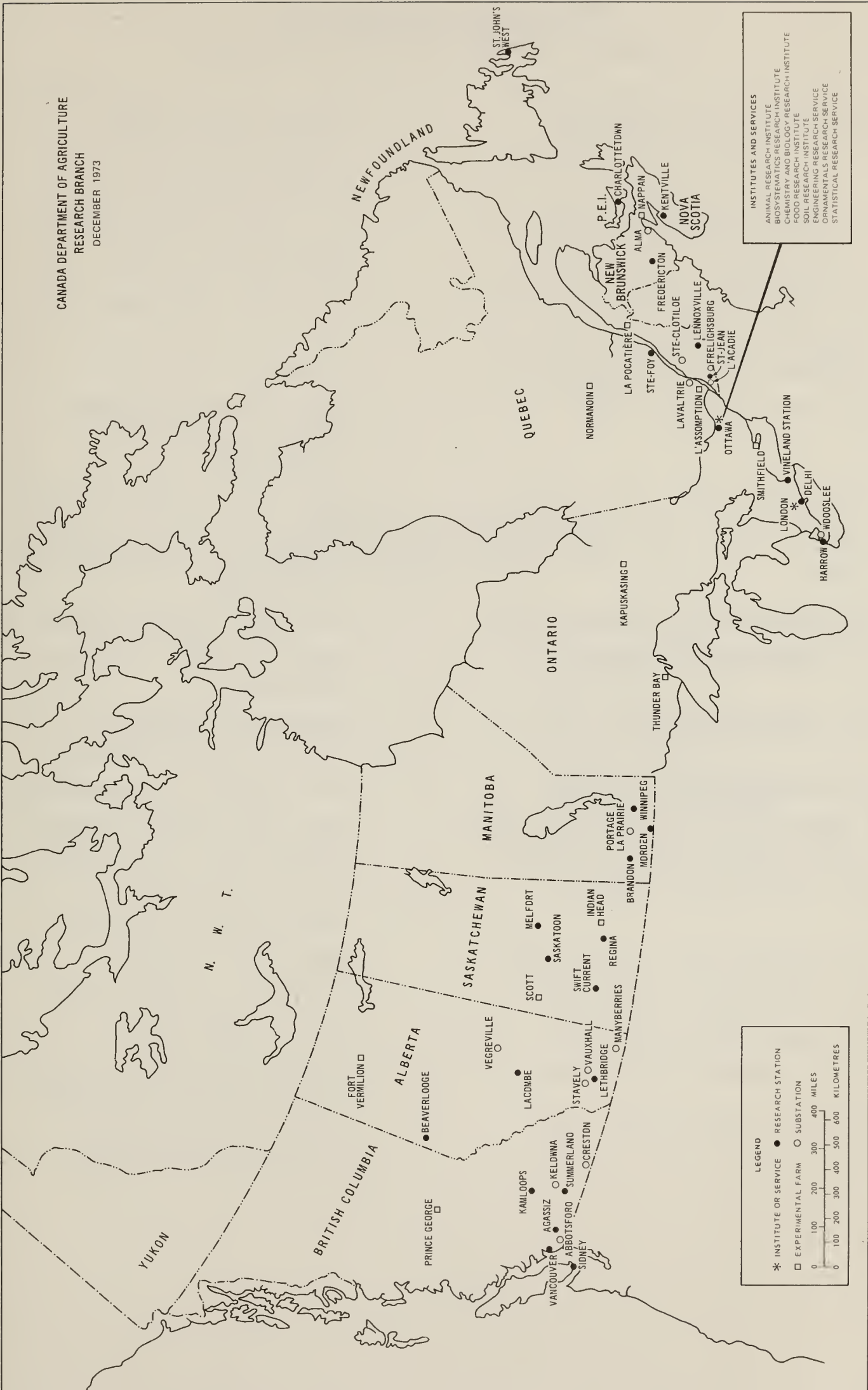
Coordinator (Executive Program)
Coordonnateur (Programmes, exécutif)

D. G. PETERSON, B.A., M.Sc.

CANADA DEPARTMENT OF AGRICULTURE
RESEARCH BRANCH



CANADA DEPARTMENT OF AGRICULTURE
RESEARCH BRANCH
DECEMBER 1973



LEGEND

- * INSTITUTE OR SERVICE
- EXPERIMENTAL FARM
- RESEARCH STATION
- SUBSTATION

0 100 200 300 400 500 600 MILES
0 100 200 300 400 500 600 KILOMETRES

INSTITUTES AND SERVICES

- ANIMAL RESEARCH INSTITUTE
- BIOSYSTEMATICS RESEARCH INSTITUTE
- CHEMISTRY AND BIOLOGY RESEARCH INSTITUTE
- FOOD RESEARCH INSTITUTE
- SOIL RESEARCH INSTITUTE
- ENGINEERING RESEARCH SERVICE
- ORNAMENTALS RESEARCH SERVICE
- STATISTICAL RESEARCH SERVICE

RESEARCH COORDINATORS

COORDONNATEURS DES RECHERCHES

E. J. LEROUX, B.A., M.Sc., Ph.D.	Assistant Director General (Planning and Coordination) <i>Directeur général adjoint</i> (Planification et coordination)
J. R. AITKEN, B.S.A., M.Sc., Ph.D.	Sheep, Swine, and Poultry <i>Mouton, porc et volailles</i>
C. J. BISHOP, B.Sc., M.A., Ph.D., F.R.S.C., F.A.S.H.S.	Horticulture <i>Horticulture</i>
J. J. CARTIER, B.A., B.Sc., M.Sc., Ph.D.	Entomology <i>Entomologie</i>
A. P. CHAN, B.Sc., M.Sc., Ph.D.	Special Advisor (Ornamentals) <i>Conseiller spécial (Plantes</i> <i>ornementales)</i>
M. F. CLARKE, B.S.A., M.S.A., Ph.D.	Forage Crops <i>Plantes fourragères</i>
C. G. E. DOWNING, B.E., M.Sc., F.A.S.A.E., F.E.I.C.	Special Advisor (Agricultural Engineering) <i>Conseiller spécial</i> <i>(Génie rural)</i>
W. S. FERGUSON, B.S.A., M.Sc., Ph.D.	Soil Fertility <i>Fertilité des sols</i>
R. L. HALSTEAD, B.S.A., Ph.D.	Pesticides (Acting) <i>Pesticides</i> <i>(Intérimaire)</i>
L. P. LEFKOVITCH, B.Sc.	Special Advisor (Statistics) <i>Conseiller spécial (Statistique)</i>
C. D. MCKEEN, B.A., M.A., Ph.D.	Plant Pathology <i>Phytopathologie</i>
E. S. MERRITT, B.Sc. (Agr.), M.Sc., Ph.D.	Dairy Cattle <i>Troupeaux laitiers</i>
C. D. F. MILLER, B.S.A., M.S.A., Ph.D.	Biosystematics <i>Biosystématique</i>
H. V. MORLEY, B.Sc., Ph.D.	Environment and Resources <i>Environnement et ressources</i>
J. W. MORRISON, B.S.A., M.Sc., Ph.D.	Cereal Crops <i>Céréales</i>
W. J. PIGDEN, B.S.A., M.Sc., Ph.D.	Beef Cattle <i>Troupeaux bovins</i>
W. J. SAIDAK, B.S.A., M.S., Ph.D.	Weeds <i>Malherbologie</i>
R. P. A. SIMS, B.Sc., Ph.D., F.C.I.C.	Field and Oilseed Crops <i>Grandes</i> <i>cultures et plantes oléagineuses</i>
D. W. WARE, B.S.A., M.S.A., Ph.D.	Special Advisor (Economics) <i>Conseiller spécial (Economie)</i>

ADMINISTRATION

R. A. LUDWIG, B.Sc., M.Sc., Ph.D., F.A.P.S.

Assistant Director General
(Administration)
Directeur général adjoint
(Administration)

J. E. RYAN, A.C.B.A., R.I.A.

Chief of Administrative Services
Section
Chef des services administratifs

D. R. KINSMAN, B.Sc.

Chief of Architectural and
Engineering Section
Chef de l'architecture et du génie
technique

EXECUTIVE PROGRAM *PROGRAMMES, EXÉCUTIF*

D. G. PETERSON, B.S., M.Sc.

Coordinator (Executive Program)
Coordonnateur (Programmes,
exécutif)

C. E. CHAPLIN, B.Sc., M.Sc., Ph.D.

Chief of Research Program
Services Section
Chef des services auxiliaires des
programmes de recherche

A. I. MAGEE, B.Sc. (Agr.), M.S.A.

Chief of Ottawa Services Section
Chef des services techniques
(Ottawa)

FOREWORD

This report is an account of the activities of the Research Branch for 1973. It is a compilation of reports, prepared by the directors and staffs of all the research establishments. It is not readily apparent, from the way in which this report is presented, that a close relationship exists among the establishments, in terms of program. Although the Branch is organized geographically, the overall program is planned, reviewed, and coordinated centrally. One of the foldouts in this report indicates this coordination operation, and illustrates the use of objectives and goals in the planning operations by the research coordinators.

The chief purpose of this report is to provide each establishment with the opportunity to account for its activities. A briefer report is being prepared wherein the overall program is presented in terms of objectives and goals. The additional report will serve as a supplement to this main report.

Several changes in activities within establishments have occurred during the past years. Some programs have been consolidated, some have expanded, and a few have been reduced. All changes are made in accordance with changes in priorities and the pressures of a changing agriculture.

Several changes in management personnel have occurred. Dr. W. B. Mountain was promoted to Assistant Director General

(Institutes and Services) and Dr. D. F. Hardwick was appointed to the Directorship of the Biosystematics Research Institute. This Institute is the result of a consolidation of the Entomology Research Institute and the Biosystematics Section of the Plant Research Institute. Dr. A. Chan became Director of the newly formed Ornamentals Research Service and also serves as special adviser to the Planning and Coordination group. A number of appointments were made to the Planning and Coordination group: Dr. C. D. McKeen (Plant Pathology); Dr. C. D. F. Miller (Biosystematics); Dr. E. S. Merritt (Dairy Cattle); Dr. J. R. Aitken (Sheep, Swine, and Poultry); Dr. W. J. Saidak (Weeds); and Dr. R. P. A. Sims (Field and Oiled Crops). Dr. D. Ware, of the Economics Branch, was seconded to the Planning and Coordination group as a special advisor. This group suffered a serious loss in the untimely death of Dr. H. Hurtig, Research Coordinator (Environmental Quality).

New directors appointed were Dr. J. E. Miltimore to the Research Station, Agassiz, and Dr. D. E. Waldern to the Research Station, Kamloops.

A biennial Branch Directors' Conference is scheduled for the spring of 1975.

B. B. Migicovsky
Director General

AVANT-PROPOS

Ce rapport décrit les activités de la Direction de la Recherche en 1973. Il s'agit d'une compilation de rapports préparés par les directeurs et le personnel de tous les établissements de recherches. A prime abord, la structure de ce rapport ne met peut-être pas en relief le fait que tous les établissements sont reliés entre eux en termes de programme. Bien que la Direction soit organisée géographiquement, le programme est dans son ensemble planifié, analysé et coordonné par les quartiers généraux. On trouvera sur l'une des pages à déplier le schéma qui reflète à la fois les mécanismes de coordination et l'utilisation de la gestion par buts et objectifs au niveau des coordonnateurs.

Ce rapport permet à chaque établissement de rendre compte de ses activités. On est à préparer une version abrégée du rapport dans laquelle tout le programme est présenté en termes d'objectifs et de buts. Ce rapport additionnel servira de supplément au rapport principal.

Il y a eu beaucoup de changements dans les divers établissements en ces récentes années. Certains programmes ont été consolidés, d'autres ont connu de l'expansion et un petit nombre ont été réduits. Tous ces changements résultent des priorités parfois changeantes que nous suggère une agriculture en évolution constante.

Il y a eu beaucoup de mutations au niveau du personnel des cadres. Le Dr W. B. Mountain a été promu au poste de Directeur

Général adjoint (Instituts et Services) et le Dr D. F. Hardwick lui a succédé comme Directeur de l'Institut de recherches biosystématiques. Cet institut résulte de la fusion de l'Institut de recherches entomologiques et de la section de biosystématique de l'Institut de recherches sur les Végétaux. Le Dr A. Chan est devenu Directeur du nouveau Service de recherches sur les Plantes ornementales et aussi conseiller spécial auprès du groupe de Coordination et de Planification. Des nominations ont eu lieu au sein des coordonnateurs: le Dr C. D. McKeen (Pathologie végétale); le Dr C. D. F. Miller (Biosystématique); le Dr E. S. Merritt (Troupeaux laitiers); le Dr J. R. Aitken (Mouton, Porc, Volailles); le Dr W. J. Saidak (Malherbologie) et le Dr R. P. A. Sims (Grandes cultures et Plantes oléagineuses). Le Dr D. Ware de la Direction de l'Économie a été mis à la disponibilité du groupe des coordonnateurs en tant que conseiller spécial. Ce groupe déplore également la mort prématurée du Dr H. Hurtig, coordonnateur de recherches (Qualité de l'environnement).

Les nouveaux directeurs de stations furent le Dr J. E. Miltimore à la Station de recherches d'Agassiz et le Dr D. E. Waldern à la Station de recherches de Kamloops.

Une Conférence biennale des Directeurs est prévue pour le printemps de 1975.

B. B. Migicovsky
Directeur Général

Research Station St. John's West, Newfoundland

PROFESSIONAL STAFF

H. W. R. CHANCEY, B.S.A., M.S.A. Director

Entomology Section

R. F. MORRIS, B.S.A., M.Sc. Head of Section; Vegetable insects

Horticulture Section

B. G. PENNEY, B.Sc., M.Sc. Vegetable crops

Plant Breeding and Pathology Section

K. G. PROUDFOOT, B.Agr., M.Agr. Head of Section; Potato breeding
M. C. HAMPSON, B.Sc., M.Sc., Ph.D. Plant diseases

Soils and Agronomy

A. F. RAYMENT, B.Sc., M.Sc. Soil fertility
P. K. HERINGA, B.Sc., M.Sc. Pedology
M. D. SUDOM, B.S.A., M.S.A. Pedology

Departure

A. SCHORI, B.Sc., M.S.A. Pedology
Resigned February 28, 1973

INTRODUCTION

The Research Station at St. John's West attempts to resolve regional agricultural problems and to conduct continuing research on peat soils and on control of potato wart, clubroot, and the golden nematode. Experimental studies on insect control, plant diseases and nutrition, and suitable crop varieties, together with soil survey work, complete the Station's research program.

This ninth report briefly summarizes the results of our research work in 1973. Copies of previous reports and reprints of publications can be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's West, Nfld. A1E 3Y3.

H. W. R. Chancey
Director

SOIL SCIENCE

Soil Survey

A soil capability for agriculture map, at a scale of 1:250,000, was completed for the Bonavista Peninsula. Potential agricultural soils were found west and south of Lethbridge, around the perimeter of Musgravetown, and on Random Island.

Field work for soil capability mapping was completed for the Highlands-Serpentine area on the west coast of the Island. Preliminary evaluation indicates that fairly extensive areas are suitable for agricultural use.

Under the leadership of the Provincial Department of Forestry, a land capability analysis map of the Island of Newfoundland was completed at a scale of 1:500,000. Land showing potential agricultural use exceeded 0.89 million ha (2.2 million ac) and substantial areas were classed as capable of high blueberry production and moderate use for livestock grazing.

Peat Soils

Drainage. Water table levels and crop yields responded markedly to drainage treatments under the unusually high precipitation of 18.11 cm in June. Yields of carrots, turnips, and potatoes planted on ridges were excellent when drained by covered "Norwegian" ditches spaced at 6.10 m and cross-drained by moles spaced at 3.05 m. With no mole drainage crop yields were low, but substantial increases were obtained with closer ditch spacings. Gypsum applied to peat soils at 6.73 and 13.46 t/ha reduced crop yields and failed to improve drainage.

Fertilizers. The effect of N, P, and K fertilizers on yields of transplanted late

cabbage varieties was greater with split applications than with single preplant applications. Plots received preplant N at 336 kg/ha plus N, P, and K side-dressings at 224 kg/ha each. The highest yield was 58.0 t/ha, including all heads weighing more than 0.68 kg. Varieties tested included Houston Evergreen, Evergreen Ballhead, Green Winter, Storage Green, and Greenhead.

Mineral Soils

Fertilizers. In the greenhouse, the addition of limestone to a very acid Cochrane soil already containing near-optimum levels of N, P, and K increased the yield of grass only slightly. Under similar conditions, gypsum increased grass yields by up to 40% and improved the soil permeability. Studies are being continued to account for this apparent anomaly.

The application of various amounts of preplanting and side-dressed N showed that increasing the rate of N from 224 to 336 kg/ha produced a 26.6% yield increase in transplanted (tp) cabbage and a 33.3% increase in direct-seeded (ds) cabbage; increasing the rate of N from 336 to 448 kg/ha increased tp yields by 23.3% and ds yields by 21.8%. Yield differences for single versus split N applications were minor in both ds and tp cabbage. Varieties tested included Pennstate Ballhead, Green Winter, Evergreen Ballhead, Storage Green, and Greenhead.

PLANT SCIENCE

Weed Control on Mineral Soil

Rutabaga (var. *York*) and *cabbage* (var. *Market Prize*). Treatments included preplanting incorporated applications of trifluralin, BAS-3921 (BASF Corp.), Devrinol (Stauffer Chemicals), and Cobex (U.S. Borax); preemergence applications of chlorthal and alachlor; and postemergence applications of MO (Chipman Chemicals) and niclofen. Devrinol at 2.8 and 3.4 kg active ingredient (ai)/ha and Cobex at 1.7 kg ai/ha gave very good control, but both caused some initial stunting. Yields with these treatments were higher than those produced with trifluralin at 1.7 kg ai/ha. Alachlor at 3.4 kg ai/ha and Cobex at 1.1 kg ai/ha gave very poor control.

Lettuce (var. *Sunblest*). Plots were treated with preemergence applications of sulfallate, chlorpropham, chlorthal, sulfallate + chlorthal, and chlorpropham + chlorthal, together with preplanting incorporated applications of trifluralin, sulfallate + trifluralin, and chlorpropham + trifluralin. Exceptionally good weed control was obtained with a combination of chlorpropham (4.5 kg ai/ha) + trifluralin (1.1 kg ai/ha), and chlorpropham (4.5 kg ai/ha) + chlorthal (9.0 kg ai/ha). Although the lettuce crop was stunted initially, yields were higher than with the recommended herbicides sulfallate and chlorpropham.

Carrots (var. *Special Nantes 616*). Treatments consisted of preemergence applications of linuron, prometryne, chlorbromuron, and monolinuron; and postemergence applications of linuron, prometryne, chlorbromuron, and solan. Postemergence applications of linuron, prometryne, and chlorbromuron each at 1.1 kg ai/ha, and monolinuron applied preemergence at 2.8 kg ai/ha gave very good weed control, whereas solan was ineffective.

Herbicide residues. A bioassay of the 1972 test plots for rutabagas and cabbages showed that there was sufficient residue of Devrinol previously applied at 1.7 kg ai/ha to severely injure lettuce and beets planted 1 yr later. There was no detectable residue of trifluralin, MO, niclofen, BAS-2903 (BASF), or BAS-3921.

Forage Crops

Pastures on peat soils. Extremely poor performance of lambs in previous grazing trials on reed canarygrass and tall fescue peat pastures suggested associated palatability or toxicity influences, or both. In 1973, weaned lambs pastured on redtop and Kentucky bluegrass gained twice as much as lambs pastured on reed canarygrass, indicating that grass species materially influenced weight gains. Use of reed canarygrass by cattle has not been a major problem, and performance of mature sheep on reed canarygrass has generally been acceptable when cobalt was supplied to prevent grass staggers or magnesium tetany caused by *Phalaris*.

Forage harvesting. A side-mounted forage harvester was adapted for use on peat soil by fitting flotation tires of 45.7-cm outside diam and 22.8-cm tread. The harvester was mounted on a 45-horsepower half-track tractor fitted with front flotation tires. In conjunction with a special tracked trailer, it was tested for direct cut and pickup of hay in a dry or semidry state from the swath. The combination was fairly versatile in these respects and was also far superior to anything yet tested in terms of flotation, maneuverability, power requirement, and general performance.

Forage preservation. Pregnant ewes wintered on silage preserved with formic acid did as well as those that received a ration of half hay and half silage. This contrasted with results in the previous year when weights of pregnant ewes fed untreated silage without supplemental hay dropped off severely. In both years much of the silage spoiled, but formic acid improved its acceptance by the sheep.

ENTOMOLOGY

Cabbage maggot

In field tests for control of root maggots in cabbage, carbofuran (2.2 kg flowable) at 3.36 kg ai/ha gave 100% control. Phoxim (2.1 kg emulsifiable concentrate (EC), BAY 92114 (2.1 kg EC; Chemagro Chemicals), and carbofuran each at 1.7 kg ai/ha gave 98% control. Fensulfothion (2.7 kg EC) at 3.36 kg ai/ha gave 97% control. Drench types of sprays were more effective than

granules when applied at equivalent concentrations. In the control plots, 76% of the plants died from a heavy infestation of root maggots.

Seed of York swede turnip pelleted with carbofuran (3.4 kg wettable powder (WP) and ST) at 240 and 320 g/100 g of seed gave only fair control (63–75%) of root maggots and caused up to 65% reduction in seedlings. Pelleting the seeds at 80- and 160-g rates gave unsatisfactory control (53–72%), but there was less phytotoxicity. The WP formulation was less phytotoxic than the ST, but phytotoxicity was eliminated when the WP was mixed with charcoal and a fungicide.

Zoecon Pherocon ICPY traps and 3M Sectar I Yellow insect traps with Cabmag-gottract attractant gave 18 to 40% control of root maggots in rutabagas. Traps at a density of 573/ha were more effective than at 286 and 660/ha. Zoecon traps with attractant averaged 118 root maggot flies per trap in a season, 3M Sectar Yellow traps with attractant averaged 123 flies per trap, and 3M Sectar Yellow traps without attractant averaged 90 flies per trap.

Golden Nematode

In an evaluation of nematicide treatments, DPX1410 (Vydate 10% granular (G) and 0.9 kg EC; DuPont of Canada Ltd.) at 33.6 kg/ha at planting followed by a foliar spray at 33.6 kg/ha completely prevented larval development in potato roots, and granular fensulfothion at 67.2 and 134.4 kg/ha significantly reduced larval infestations in roots. These reductions were not reflected in crop yield and no detrimental or beneficial effects from the nematodes were observed in any of the plots.

PLANT BREEDING AND PATHOLOGY

Potato Breeding for Resistance to Wart and the Golden Nematode

Wart infections occurred on plants of both Pink Pearl and N48-237, apparently caused by a strain of the wart fungus similar to European race 8. Fortunately, several of our seedlings are resistant to this race, including N135-55, a cross between Mira and the Fredericton selection 5318. Highly satisfactory yields have been obtained from this midseason, white-fleshed potato, and grower

evaluation trials at 15 centers showed no wart infection. Application to license and name N135-55 will be made in 1974.

Selections resistant to wart and the golden nematode were evaluated in replicated trials at five regional centers. Both the nematode-resistant variety Wauseon and selection N227-L5 yielded less than Kennebec and several wart-resistant selections. Overall average yield of N170-261, derived from F5318 and from an andigena cross, was higher than Kennebec. Unfortunately, tuber dormancy of N170-261 is short, since sprouting occurs by mid-December.

Brassica Breeding for Resistance to Clubroot

A breeding program was started to produce commercially acceptable rutabagas resistant to clubroot. Initial breeding stocks were obtained from the Research Station at Charlottetown, where a similar program is now being completed.

Crosses between rutabagas and turnip-rutabaga hybrids containing resistance to several races of clubroot produced seed, and 18 oilseed rape selections were screened for resistance to the organism. Except for Zephyr, which produced some disease-free plants, none of the rapes were resistant. White turnips of Dutch origin were resistant to the race(s) present in the test plots.

Germination and Infectivity of Potato Wart Sporangia

In research studies designed to obtain optimum germination of resting sporangia, culture contamination continued to be a problem, even after sporangia were treated with javelle water, ethanol, chlortetracycline, polymixin B, chloramphenicol, streptomycin, and rose bengal. Because *Pseudomonas* colonies grew in sterile filtered extracts, the tuber extract may have contained a pseudomonad flora, possibly with filterable forms. A perfusion apparatus is now being developed to control contaminating flora in test extracts and sporangia cultures.

In cultures of race 8 wart sporangia, a consistently high number (98%) of heterokontous biflagellate zoospores were found that stained with Leifson's flagella stain. It is suggested that racial differences in morphology may exist in *Synchytrium endobioticum* biotypes.

In continuing work on potato wart infectivity with race 2, the interaction of soil temperature, moisture, and seasonal advance was recorded. Typical winter infection values

were 61%, 75%, and 52% for 1-, 2-, and 3-wk irrigation periods after planting, respectively. These results suggest that a deficiency or excess of moisture inhibits infection.

PUBLICATIONS

Research

Hampson, M. C. 1973. Design and construction of an inexpensive controlled environment room for the study of soil borne plant diseases. *BioScience* 23:174-175.

Hampson, M. C. 1973. Photographing the secondary fluorescence of potato wart fungus resting sporangia in color. *J. Biol. Photog. Assoc.* 41(2):37-38.

Hampson, M. C., and Sinclair, W. A. 1973. Xylem dysfunction in peach caused by *Cytospora leucostoma*. *Phytopathology* 63:676-681.

Morris, R. F. 1973. Note on the occurrence of the black witch moth, *Erebus odora* (Lepidoptera: Noctuidae) in Newfoundland. *Can. Entomol.* 105:1151.

Rayment, A. F., and Heringa, P. K. 1972. The influence of initial and maintenance fertilizers on the growth and ecology of grass-clover mixtures on a Newfoundland peat soil. *Proc. 4th Int. Peat Congr.* 4(3):111-120.

Wells, R. E., and Heringa, P. K. 1972. Soil survey of the Gander-Gambo area, Newfoundland. Report No. 1, Newfoundland Soil Survey. Can. Dep. Agric., Ottawa.

Miscellaneous

Hampson, M. C., and Proudfoot, K. G. 1973. Potato wart research in Newfoundland. *Can. Agric.* 18(1):23-25.

Morris, R. F. 1972. (A) Root maggot control on swede turnips by seed pelleting, and (B) Chemical control of root maggots in cabbage. *Can. Hortic. Counc. Rep.* 1972:2.

Morris, R. F., and Proudfoot, K. G. 1973. The golden nematode. *Can. Agric.* 18(2):11-13.

Proudfoot, K. G. 1972. Evaluation of potato selections for resistance to potato wart and golden nematode. *Can. Hortic. Counc. Rep.* 1972:2.

Rayment, A. F., and Heidel, D. 1972. Harvesting, storage and animal utilization of forage produced on Newfoundland peat soils—a preliminary report. *Proc. 18th Meet. Can. Soc. Agron.* pp. 31-40.

Research Station

Charlottetown, Prince Edward Island

PROFESSIONAL STAFF

L. B. MACLEOD, B.Sc. (Agr.), M.Sc., Ph.D.	Director
D. A. HUTCHINSON	Administrative Officer
B. STANFIELD, B.S.A., M.S.A., M.L.S.	Librarian

Cereal and Tobacco Section

J. D. E. STERLING, B.S.A., M.Sc.	Head of Section; Breeding (barley)
H. W. JOHNSTON, B.Sc. (Agr.), M.Sc., Ph.D.	Diseases (cereal)
K. E. LELACHEUR, B.Sc. (Agr.)	Tobacco
J. A. MACLEOD, B.Sc. (Agr.), M.Sc., Ph.D.	Nutrition (forage and cereal)
H. G. NASS, B.S.A., M.Sc., Ph.D.	Physiology (cereal), breeding (wheat)
J. B. SANDERSON, B.Sc. (Agr.)	Management (winter cereals and protein crops)

Forage Section

C. B. WILLIS, B.Sc. (Agr.), Ph.D.	Head of Section; Diseases (forage)
W. N. BLACK, B.Sc. (Agr.)	Nutrition (pasture and corn)
U. C. GUPTA, B.Sc. (Agr.), M.Sc. (Agr.), Ph.D.	Micronutrients (soil and plant)
J. KIMPINSKI, B.S.A., M.Sc., Ph.D.	Nematology
M. SUZUKI, B.Sc., Ph.D.	Biochemistry and physiology (forage)
L. S. THOMPSON, B.Sc. (Agr.), Ph.D.	Insects (forage, cereal, and vegetable)
R. P. WHITE, B.S. (Ed.), M.S., Ph.D.	Nutrition (corn and potato), soil chemistry

Crop-Livestock Systems Section

J. H. LOVERING, ¹ B.Sc., M.A., Ph.D.	Head of Section; Economics (production)
H. T. KUNELIUS, B.Sc., M.Sc., Ph.D.	Physiology and management (forage)
J. A. McISAAC, ¹ B.Sc.	Systems engineering

D. G. RUSSELL,¹ B.Sc. (Agr.), M.Sc., Ph.D.
K. A. WINTER, B.Sc. (Agr.), M.Sc., Ph.D.

Economics (systems)
Nutrition (cattle)

Horticulture Section

J. A. CUTCLIFFE, B.Sc. (Agr.), M.Sc.

G. W. AYERS, B.Sc. (Agr.), M.Sc.
L. C. CALLBECK, B.Sc. (Agr.)
J. A. IVANY, B.Sc. (Agr.), M.S., Ph.D.

J. P. MACKINNON, B.Sc. (Agr.), M.Sc.
D. C. MUNRO, B.S.A., M.Sc.
D. C. READ, B.Sc. (Agr.), M.Sc., Ph.D.

Head of Section; Nutrition and
management (vegetable)
Diseases (crucifer and potato)
Diseases (potato)
Weed control (vegetable, forage,
and cereal)
Diseases (potato)
Nutrition (potato and vegetable)
Pesticide bioactivity, insects
(vegetable)

¹Seconded from Economics Branch.

INTRODUCTION

The Research Station at Charlottetown has regional responsibility for research into the production of forages, cereals, tobacco, and vegetable crops grown for processing. Research is also conducted on local problems with potatoes, cattle nutrition and breeding, and small fruits. This report summarizes the results from selected research projects; further information on the results presented, or on other aspects of the research program, may be obtained from the Station or individual scientists.

In July 1973, Mr. J. P. MacKinnon transferred here from the Research Station, Fredericton, N.B., to conduct research on virus diseases of potatoes. Dr. D. G. Russell joined the Economics Branch and was seconded to the Station in September to conduct research on crop-livestock systems. In November, Mr. B. Sanderson joined the staff as a biologist to strengthen the research program on the management and production of winter cereals (winter wheat and fall rye) and protein crops.

On July 3, the Station hosted Her Majesty Queen Elizabeth II and His Royal Highness Prince Philip as part of their 4-day visit to Prince Edward Island for the Centennial Celebrations.

On July 24, Hon. Eugene F. Whelan, Minister of Agriculture, and Hon. Alex B. Campbell, Premier and Minister of Agriculture and Forestry of Prince Edward Island, officially opened the new agricultural research and extension complex on the Station.

Copies of this report and reprints of the scientific papers listed may be obtained from: Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8.

L. B. MacLeod
Director

CEREALS

Breeding and Testing

Barley. Barley selection AB 9-1, which is resistant to barley jointworm, continued to yield well in comparative trials. The selection also has high resistance to smuts. It shows some tolerance for soils with low pH but is inferior to Volla in this regard. A license will be applied for in 1974.

Loyola, the newest variety recommended for the Maritime Provinces, gave the highest yields in most of the trials, but it has weak straw and tends to drop its heads.

Bonanza, which was developed primarily as a malting barley for Western Canada, appeared to be superior to Keystone in yielding ability and equal to it in lodging resistance under maritime conditions in 1973.

Oats. Selection AO 9-4 from Orbit × Dorval indicated a superior combination of yield, early maturity, and kernel quality in trials in the Maritimes. It has moderate resistance to lodging.

Spring wheat. A selected awned strain (a Kentville selection) from Opal continued to look promising. It is probable that a license

will be applied for in 1974. A number of strains from the crosses Inia × Opal and Pitic × Opal were earlier maturing and higher yielding than Opal.

Fababean evaluation. Early maturing fababean cultivars show most potential in Prince Edward Island. Seed yields of the best cultivars were up to 4,200 kg/ha in 1973, and 3,200 kg/ha in 1972. Crude protein content ranged from 25% to 30%. No serious pest problems limiting the growth of fababeans have been encountered during the past 2 yr.

Cereal Management and Nutrition

Date of seeding. A study of seeding dates substantiated results obtained in 1972; seeding as early as possible in the spring resulted in maximum yields. Delayed seeding increased lodging and diseases, decreased bushel weight, and delayed maturity considerably. The highest yields for oats and barley were obtained from the seeding on May 2. Seeding on June 6 and June 18 reduced yields of Keystone barley by 14 and 16 kg/ha, and those of Garry oats by 15 and 20 kg/ha. Seeding in June delayed maturity 3–5 wk compared with seeding on May 2.

Fertilizer damage. Damage to cereals by fertilizers containing urea and diammonium phosphate was caused by an accumulation of NH_3 near the developing root. Ammonia damage could be distinguished from osmotic damage caused by high concentrations of NH_4NO_3 and KCl by the relatively greater effect of NH_3 on root than on shoot development. In severe cases of NH_3 damage, the root was destroyed as it emerged from the seed coat.

Toxicity of Al and Mn in barley. Al toxicity resulted in abnormal root development with many short thick roots. The Mn toxicity symptoms on the leaves appeared as dark spots, which were translucent; the roots were thin with little lateral branching. Al was more detrimental to seedling development than Mn. No kernels developed when the Al concentration of saturated extract of soil was greater than $10 \mu\text{g/ml}$.

Winter injury to winter wheat. During the winter of 1972–73, it was observed that 70% of the winter wheat plants on Prince Edward Island were moderately to severely injured. Half of them, however, showed excellent recovery in late spring and early summer. Time of seeding, seeding depth, and application of K and Zn showed little effect on winter survival.

Herbicides for control of hemp-nettle in cereals. The herbicides were applied to hemp-nettle when it was 2.5–5.0 cm tall and in the two-leaf stage. The amine and estemine formulations of 2,4-D at 0.42 litre active ingredient (ai)/ha and mecoprop at 0.70 litre ai/ha gave no control. The amine, sodium salt, and estemine formulations of MCPA at 0.70 litre ai/ha gave 70–80% control. Diquat at 0.14 litre ai/ha gave 95% control.

N corrects moderate B toxicity in cereals. The addition of compost to the soil mixture resulted in B toxicity characterized by brown spotting and a burned appearance on older leaf tips. The addition of N decreased the severity of these symptoms. When N was applied at 150 ppm, B toxicity was negligible. Added N decreased B concentrations in tissues of barley and wheat at the boot stage from 38 to 23 ppm and from 18 to 10 ppm.

Annual seeding costs for cereals. Seeding costs for cereals were found to vary by only \$4.40/ha for machinery complements requiring tractors that ranged between 49 and 104

hp (50 and 105 hp SAE). Costs included all machines, labor, and the value of crop-yield losses incurred by seeding after a specified date. The machinery included a tractor, plow, harrow, disc, and seeder. The investment in this machinery was from \$130 to \$247/ha in a cereal enterprise of 91 ha.

Cereal Diseases and Insects

Seed source and treatment. Observations on the microbial seed contamination of Volla and Keystone barley grown at 10 locations across Canada revealed that seed produced in Western Canada had high populations of storage fungi such as *Penicillium* and *Aspergillus* and low levels of *Helminthosporium*. Seed of the same varieties grown in the Maritimes was contaminated with a few *Penicillium* and *Aspergillus* and high levels of *Helminthosporium*. When treated with Vitaflo (UniRoyal Chemical), seed from the Maritimes produced crops with yields as high as those from untreated seed from Western Canada. Similar treatment of western seed indicated the possibility of depressed yields.

Control of barley yellow dwarf virus and aphids on grain. Greenhouse and field evaluations of selected germ plasm from wheat, oats, and barley indicated that several of each species may have high levels of tolerance for the barley yellow dwarf virus (BYDV) disease.

A field experiment designed to determine the effect of a disulfoton–fertilizer combination on grain aphids, BYDV, and yield of oats and barley indicated that barley yields were increased by 30% and oats by 25% in the absence of aphids and BYDV.

Aphids on fababeans. Aphids were not a problem in 1973. However, increased yields of Ackerperle fababeans were recorded in plots treated approximately 4 wk after seeding with disulfoton 15% G at 226 g ai/300 m of row. Treating seed before planting with menazon at 6 g 70% wettable powder/kg resulted in reduced yields.

FORAGES

Nematology

Nematodes in forage legumes. Eight genera of potentially plant-parasitic nematodes are associated with alfalfa, red clover, and birdsfoot trefoil in New Brunswick. The identity has been confirmed of 24 species in

12 genera of potentially parasitic nematodes associated with forage legumes in Prince Edward Island. *Pratylenchus penetrans* (Cobb) and *P. crenatus* Loof were each found alone in 27% of the samples and mixed together in 46% of the samples. Numbers of *P. penetrans* were greater than *P. crenatus* in soil and root samples.

Population dynamics of root-lesion nematodes. Three generations of *P. penetrans*, each lasting about 6 wk, occurred after the nematodes invaded red clover roots in the seeding year. The average numbers of nematodes per plant in the first, second, and third generations were 40, 579, and 1,534.

Nematode control. Supplementary applications of Nemacur (Chemagro Corp.) or Vydate (DuPont of Canada Ltd.) to plots of birdsfoot trefoil established and initially treated in 1971 resulted in increases up to 150% in plant stands in the spring of 1973 on treated plots as compared with untreated plots. The number of *Pratylenchus* spp. found in rootlets was, on the average, 78% lower in the plots treated with nematicide. Spraying birdsfoot trefoil with Vydate at 4.48 kg ai/ha three times after seeding increased yields of dry-weight foliage of second cuts by 25% above the controls, whereas spraying at 5-wk intervals increased yields by 43%. The numbers of *Pratylenchus* spp. in the rootlets were 34% and 77% lower.

Nematodes in corn. Root-lesion nematodes, *Pratylenchus* spp., were the dominant nematode species present in root samples of field corn in Prince Edward Island, but no correlation was found between crop yield and nematode numbers.

Nutrition

Mineral balance in timothy. Timothy fertilized with N, P, and K at 66, 10, and 56 kg/ha produced forage with Mg levels below 0.25% and K/Ca + Mg ratios above 2.2 on June 5 and 14. Grass tetany may be a problem in cattle grazing pastures with these mineral balances unless Mg supplementation is provided in the diet. Fertilization with Mg did not produce timothy forage with satisfactory mineral balance.

Boron nutrition of timothy. Added B did not result in yield increases, although values as low as 2.8 ppm B in the tissue were obtained. Concentrations of B of greater than 102 ppm in tissue were associated with

decreased yields. Liming the soil to pH 6.5 decreased the yield of timothy. This decreased yield was not corrected by applied B and was probably caused by Mn deficiency.

Corn nutrition. When other nutrients were not limiting, no yield responses of silage corn occurred at two locations with additional amounts above the base rates of 45 kg N/ha, 56 kg P/ha, and 0 kg K/ha applied in separate experiments. Current soil test recommendations are above these rates.

When N was applied at 0 to 280 kg/ha in a 4-yr experiment on silage corn, no yield responses occurred above 56 kg N/ha in the first 3 yr and 112 kg N/ha in the 4th year. In the first 3 yr, the annual N uptake averaged 67, 109, 118, and 128 kg/ha when N was applied yearly at 0, 56, 112, and 250 kg/ha.

No silage corn yield responses occurred when yearly rates of K from 0 to 186 kg/ha were applied for 4 yr to a soil initially testing 247 kg K/ha. The average annual uptake over the first 3 yr was 90 to 128 kg K/ha, increasing as applied K increased. Soil test levels declined at K rates below 139 kg/ha and increased at the 186-kg rate. With no applied K, the soil test declined to, and remained at, approximately 140 kg K/ha after 1 yr.

Physiology and Management

Winter survival of forage crops. Losses of alfalfa, birdsfoot trefoil, and clover plants in the winter of 1972–73 were 25%, 50%, and 30% in Prince Edward Island and 15%, 20%, and 30% in the Atlantic Provinces. There was little or no damage to forage grasses. Most of the alfalfa and birdsfoot trefoil plants survived until April, whereas the clover plants were often killed in midwinter. In most cases, lethal damage to alfalfa and birdsfoot trefoil occurred in April and May. Under controlled environmental conditions, a low soil-moisture level (40–50% field capacity) was optimum for hardening alfalfa plants before cold treatment. However, a higher level of soil moisture (100–300% field capacity) was required after cold treatment for recovery from desiccation injury and for vigorous regrowth. Infestation with *Pratylenchus* spp. resulted in the failure of alfalfa to survive freezing temperatures (minimum of -8°C).

Establishment of birdsfoot trefoil. Nitrogen fertilizer for direct-seeded trefoil during the establishment year was justified only on hand-weeded areas having low available soil

N. An Embutox E (May and Baker (Canada) Ltd.) + dalapon treatment controlled the weeds but also suppressed birdsfoot trefoil and resulted in poor response to applied N. When no weed control was used, N promoted the growth of weeds, which in turn suppressed birdsfoot trefoil and resulted in yields heavily infested with weeds.

Lime pelleting of alfalfa seed. On soils with a pH of 5.7 or less, lime pelleting of alfalfa seed inoculated with rhizobia resulted in dry-matter yields up to 69% higher than those from seed inoculated only. The yield increases due to lime pelleting of seed were much greater from the second cutting than from the first cutting. Inoculating the seed as recommended resulted in small yield increases. Adding Mo to inoculated seed further increased the yields of alfalfa.

Seasonal pasture production sustained by split N treatments. Under rotational grazing management, manured and unmanured areas of a natural permanent pasture sward consisting of timothy, Kentucky bluegrass, and wild white clover were subjected to seven annual fertilizer treatments over a 6-yr period with P and K at 119 and 223 kg/ha respectively, in the early spring, plus N at 0 to 336 kg/ha in three equal split treatments (mid-June, -July, and -August). All N treatments with or without manure resulted in significant yield increases. Mean dry-matter production reached a maximum of 14.78 t/ha with 336 kg N/ha. At rates of 224 kg N/ha and higher, yields were significantly increased and production was sustained during August, September, and October.

Manure applied at 22.4 t/ha as a fall dressing, at the beginning of each 3-yr study cycle, increased the annual production of dry matter by only 0.78 t/ha. No beneficial effect on yields was obtained when the amount of N applied annually was over 112 kg/ha.

Corn management. Yields of corn silage dry matter (DM) declined after the first killing frost. Yields at successive 10-day intervals after this frost were 86%, 86%, 85%, 76%, and 75% of that at the frost. However, the DM in the silage increased from 22% to 33% and in the grain the DM increased from 44% to 64% in the same period.

HORTICULTURAL CROPS

Potato Nutrition and Management

Fertilizers and seeding dates. Urea applied at 135–200 kg N/ha delayed emergence and restricted early growth of potatoes when compared with NH_4NO_3 at equal rates of N. Tuber yields were lower from the urea treatments, but tuber dry-matter content was unaffected. No differences due to N source occurred at 67 kg N/ha. Diammonium phosphate, triple superphosphate, and ordinary superphosphate were equally good sources of P. Potatoes did not respond to Mg and S applications in the fertilizer. As planting dates were delayed from May 17 to June 28, yields of Kennebec decreased from 18.6 to 11.2 t/ha, the sp gr of the tubers decreased from 1.084 to 1.074, and the percentage of tubers heavier than 454 g decreased from 24% to 8%.

Effect of Sencor on yield of Sebago. Sencor (Chemagro Corp.) was applied at 1.12 kg/ha before potatoes emerged and at 1.12 and 2.24 kg/ha as an early postemergence (potatoes 30 cm tall) and a late postemergence (potatoes 40 cm tall) treatment in 1973. Highest yields, equal to those from hand-weeded controls, were obtained from plots that were given preemergence applications. Application of 1.12 kg/ha resulted in yield reductions of 3.5% when applied early postemergence and 19.0% applied late postemergence. Application of 2.24 kg/ha resulted in yield reductions of 12.0% when applied early postemergence and 23.0% applied late postemergence. Weed control was excellent from all applications.

Potato Diseases

Control of late blight. Rigid screening tests have shown that maneb, mancozeb, metiram, and tetrachloroisophthalonitrile are the most efficacious chemicals used now in the preparation of fungicides for the control of potato late blight, *Phytophthora infestans* (Mont.) de Bary. Triphenyltin acetate and triphenyltin hydroxide have given moderate to good control but are likely to be phytotoxic unless suitable safening agents are formulated with them. A mixture of 34% maneb and 11.5% of a triphenyltin has shown promise as a good fungicide with no deleterious effects on the plants.

Diseases affecting potato tubers. High resistance to decay caused by *Fusarium sambucinum* Fckl. f. 6 Wr. was demonstrated in tuber stocks of the varieties Hunter, Purple Chief, Dorita, and Irish Cobbler. Similar testing for resistance to *F. coeruleum* (Lib.) Sacc. showed high resistance in tubers of Sebago and Irish Cobbler varieties and of two Fredericton seedlings. Almost complete immunity to decay caused by this organism was noted in tubers of the Dorita, Kennebec, and Wauseon varieties. Moderate to high resistance to wilt caused by *Verticillium albo-atrum* Reinke & Berth. was shown by the variety Abnaki and by five Fredericton seedlings. Three years of testing have shown that formulations of the systemic fungicides benomyl and thiophanate-methyl are highly effective when used as potato seed treatments for the control of seed-borne verticillium wilt and fusarium decay of seed pieces. Treatments were applied to cut seed at 10 g dust/kg seed.

Detection of potato virus S (PVS). Tubers were winter tested on the indicator host, *Nicotiana debneyi* Domin., to detect PVS, PVX, and PVY as an important part of the virus-free programs in New Brunswick and Prince Edward Island. To determine the reliability of this test for detecting PVS, comparisons were made by serologically testing eye-indexed plants grown from the same tubers. Of 76 tubers tested, 41 were shown to be infected with PVX by the *N. debneyi* test, 40 by serology of indexed plants at the 30-cm stage, and 42 when the same plants were serologically tested at bloom stage, 1 mo later.

Disease-free potatoes. Tubers were winter tested for freedom from bacterial ring rot, PVS, PVX, and PVY. No infections of ring rot, PVX, or PVY were found, but six tubers infected with PVS were detected. These were discarded, and the remaining tubers were used to plant the 1973 Pre-elite plot, first stage of multiplication. All three classes, Pre-elite, Elite I, and Elite II, at the seed farm were serologically tested during the summer for PVS and PVX.

Vegetable Nutrition and Pest Control

Effect of N, P, and K on cauliflower yields. Broadcast applications of N and P increased the yields of cauliflower at three locations, whereas applications of K had much less effect. Optimum yields were obtained where

N was applied at 112 kg/ha, P at 49–98 kg/ha, and K at 0–93 kg/ha. These results are in keeping with those of similar experiments conducted in 1972.

Fertilizer applications for Brussels sprouts. Banded applications of N resulted in greater yields of Brussels sprouts than when the fertilizer was either broadcast or broadcast and applied as a topdressing. Yields were not affected by the method of application of P, and neither the rate nor the application method for K significantly affected yields. Optimum yields were obtained where N was applied at 112–224 kg/ha and P at 49–98 kg/ha.

Clubroot resistance in a rutabaga–turnip hybrid. A rutabaga–turnip hybrid bred for resistance to clubroot was exposed to races 1, 2, 3, and 6 of the clubroot organism, *Plasmodiophora brassicae* Wor., and found to have immunity or a high measure of resistance to each race. Races under test were representative of practically all clubroot inocula found in Canadian soils. Resistance to race 1 in the new hybrid constitutes a breeding achievement because all other breeding lines and established commercial varieties of rutabagas are completely susceptible to this race. The hybrid is purple topped, yellow fleshed, globe shaped, and has foliar characteristics similar to those of rutabaga.

Bioactivity of new insecticides. Rates of toxification and detoxification of pesticides in field microplots took longer for compounds such as trichloronat (1½–2 yr), which was more persistent than phoxim > chlorophoxim > Nemacur > AC92100 (Cyanamid of Canada Ltd.) > Zinophos (Cyanamid of Canada Ltd.) > propoxur > C10015 (Ciba Giegy Canada Ltd.) > phorate > parathion (60–70 days) when the parent compounds were banded 2.5 or 5 cm below the soil surface than when they were mixed into the same depth of surface soil. There were only slight differences in rates of change in toxicity of fensulfothion, fonofos, N2596 (Stauffer Chem. Co.), and pirimiphos-ethyl. However, the rate of toxification of pirimiphos-ethyl was erratic after the band application but quite consistent when mixed with the soil. All compounds degraded to nontoxic metabolites much faster when applied on the soil surface. The nematicide, Nemacur, and the herbicide, dinoseb, were strongly insecticidal.

Toxicants of all the compounds, except Zinophos, were absorbed by rutabagas, although levels and persistence varied greatly. Toxic metabolites of Namacur and the carbamates were concentrated most highly in the pulp, whereas toxicants of all other organophosphorus compounds tested were found almost exclusively in the peel.

Nematodes. Nematodes of the genera *Pratylenchus*, *Meloidogyne*, *Paratylenchus*, *Helicotylenchus*, *Heterodera*, *Tylenchorhynchus*, and *Ditylenchus* were recovered from the surrounding soil and the roots of rutabagas, carrots, broccoli, cauliflowers, Brussels sprouts, peas, and strawberries in Prince Edward Island. *Aphelenchoides* spp. were also found on the aboveground parts of strawberries. There were no significant correlations between numbers of nematodes and yield.

TOBACCO

Hill transplanting of flue-cured tobacco. Transplanting tobacco in soil that was hilled had no effect on root development, subsequent growth, or maturity when compared with normal transplanting on unhilled land.

CATTLE NUTRITION

Urea for young calves. Holstein bull calves weaned at 5 wk were fed soybean meal or urea-supplemented starter rations either twice daily or free-choice. Replacing soybean meal with urea reduced animal performance less than feeding twice daily as compared

with free-choice and with no harmful effects even when the urea rations were fed twice daily. The reduced costs and acceptable gains with the urea starter rations make this a desirable feeding system for young calves.

Urea for potato-fed steers. Heavy Holstein steers finished on full-feed potatoes received a supplement based on either urea or soybean meal. After adaptation to the urea supplement, both groups of steers showed similar gains and intakes of potatoes. Withdrawal of the supplement markedly reduced the rate of gain.

Rye for growing steers. Young growing steers were fed restricted amounts of corn silage plus a grain ration free-choice. Rye replaced 20%, 40%, and 60% barley in the grain ration. Gains averaging 1.2 kg/day and grain intakes ranging from 2.6 to 2.7 kg/day were not significantly affected by the level of rye in the ration. These results indicate that up to 60% ergot-free rye is useful in this type of ration.

Choice of ration and class of feeder cattle. A comparison was made of net returns from feeder cattle alternatives, varying widely in average daily gain and length of keep. Feed rations based on hay, grass silage, and corn silage indicated that the corn silage ration offered feeding economies of up to \$35/head over the hay ration and up to \$23/head over the grass silage ration. Average daily gain and the price of grain supplements to the forage-based rations were found to be important factors in determining the relative profitability of the various feeder alternatives.

PUBLICATIONS

Research

Black, W. N., and White, R. P. 1973. Effects of nitrogen, phosphorus, potassium, and manure factorially applied to potatoes in a long-term study. *Can. J. Soil Sci.* 53:205-211.

Callbeck, L. C. 1973. Screening of potato fungicides in 1972. *Can. Plant Dis. Surv.* 52:151-152.

Chiykowski, L. N., Colpitts, S. R., Coulombe, L. J., Delbridge, R. W., Gourley, C. O., Lawrence, C. H., Murray, R. A., Santerre, J., and Thompson, L. S. 1973. Strawberry green petal disease in Quebec and the Maritime Provinces,

1971 and 1972. *Can. Plant Dis. Surv.* 53:63-66.

Clark, R. V., and Johnston, H. W. 1973. Tolerance of oats to the septoria disease. *Can. J. Plant Sci.* 53:471-475.

Cutcliffe, J. A., and Munro, D. C. 1973. Effects of nitrogen, phosphorus, and potassium on rutabaga yields. *Can. J. Plant Sci.* 53:357-361.

Gupta, U. C., and Cutcliffe, J. A. 1973. Boron nutrition of broccoli, Brussels sprouts, and cauliflower grown on Prince Edward Island soils. *Can. J. Soil Sci.* 53:275-279.

- Gupta, U. C., and MacLeod, J. A. 1973. Boron nutrition and growth of timothy as affected by soil pH. *Commun. Soil Sci. & Plant Anal.* 4:389-395.
- Gupta, U. C., MacLeod, J. A., and MacLeod, L. B. 1973. Effects of aluminum, manganese and lime on toxicity symptoms, nutrient composition, and yield of barley grown on a podzol soil. *Plant & Soil* 39:413-421.
- Gupta, U. C., Sterling, J. D. E., and Nass, H. G. 1973. Influence of various rates of compost and nitrogen on the boron toxicity symptoms in barley and wheat. *Can. J. Plant Sci.* 53:451-456.
- Ivany, J. A., and Cutcliffe, J. A. 1973. Herbicides for cole crops in Eastern Canada. *Proc. Northeast Weed Sci. Soc.* 27:194-198.
- Ivany, J. A., and Sweet, R. D. 1973. Germination, growth, development, and control of *Galinsoga*. *J. Weed Sci. Soc. Am.* 21:41-45.
- James, W. C., Shih, C. S., Callbeck, L. C., and Hodgson, W. A. 1973. Interplot interference in field experiments with late blight of potato (*Phytophthora infestans*). *Phytopathology* 63:1269-1275.
- James, W. C., Shih, C. S., Hodgson, W. A., and Callbeck, L. C. 1973. A method for estimating the decrease in marketable tubers caused by potato late blight. *Am. Potato J.* 50:19-23.
- Jenkins, K. J., and Winter, K. A. 1973. Effects of selenium supplementation of naturally high selenium swine rations on tissue levels of the element. *Can. J. Anim. Sci.* 53:561-567.
- Nass, H. G. 1973. The determination of characters for yield selection in spring wheat. *Can. J. Plant Sci.* 53:755-762.
- Suzuki, M. 1973. Winterkill patterns of forage crops and winter wheat. *Can. Plant Dis. Surv.* 52:156-159.
- Thompson, L. S., Cutcliffe, J. A., Gourley, C. O., and Murray, R. A. 1973. Evaluation of several insecticides for control of strawberry green petal disease. *Can. Plant Dis. Surv.* 53:16-18.
- Willis, C. B., and Thompson, L. S. 1973. Control of *Pratylenchus penetrans* in birdsfoot trefoil with oxamyl. *Plant Dis. Rep.* 57:237-240.
- Winter, K. A., Gupta, U. C., Nass, H. G., and Kunelius, H. T. 1973. Selenium content of feedstuffs produced in Prince Edward Island. *Can. J. Anim. Sci.* 53:113-114.
- Winter, K. A. 1973. Urea as a nitrogen supplement in starter feeds for early weaned calves. *Can. J. Anim. Sci.* 53:339-343.

Miscellaneous

- Ayers, G. W., and LeLacheur, K. E. 1973. Selection and breeding for clubroot resistance in rutabagas 1953-1973. *Can. Agric.* 18(4):29-31.
- Black, W. N., and White, R. P. 1973. Removal of potassium by corn silage. *Canadex* 530.
- Callbeck, L. C. 1973. Screening late blight fungicides. *Canadex* 258.630.
- Callbeck, L. C. 1973. Screening potato top killers. *Canadex* 258.20.
- Callbeck, L. C., and Arsenault, W. J. 1973. Screening late blight fungicides. *Canadex* 258.630.
- Callbeck, L. C., White, R. P., and Munro, D. C. 1972. Handling the potato crop. *Agromart Rep. C.I.L. Publ.* 4 pp.
- Cutcliffe, J. A., and Munro, D. C. 1973. Effect of nitrogen, phosphorus and potassium on rutabaga yields. *Canadex* 163.532.
- Glencross, A., and Lovering, J. 1973. A guide to retail farm machinery prices in Prince Edward Island. *P.E.I. Dep. Agric. & For. Publ.* 13 pp.
- Glencross, A., McIsaac, A., and Armstrong, D. 1973. How to obtain better machinery parts service. *Atl. Agric. Eng. Comm. Publ. No.* 5.
- LeLacheur, K. E. 1973. A comparison of elements in cured tobacco leaf. *The Lighter* 43(2):16-17.
- Lovering, J., and MacMinn, D. 1973. Estimating costs of beef production. *Can. Dep. Agric. Publ.* 1506. 53 pp.
- Nass, H. G. 1973. Fall rye—potential for the Maritimes. *Canadex* 117.
- Nass, H. G., Sterling, J. D. E., and Johnston, H. W. 1973. Recommended seeding rates of spring cereals in P.E.I. are adequate. *Canadex* 110.22.
- Suzuki, M. 1973. Is winterkill predictable? *Can. Agric.* 18(4):10-11.
- White, R. P. 1973. Early planting of corn critical to maturity of silage. *Canadex* 111.20.
- White, R. P., and Ivany, J. A. 1973. Atrazine residue evaluation. *Canadex* 609.
- Winter, K. A., Baker, M. F., and Dickieson, R. W. 1973. Dairy cattle herd health—activity schedule. *Atl. Prov. Livestock Comm. Bull.*
- Winter, K. A., and Sterling, J. D. E. 1973. Rye grain in high-energy steer rations. *Canadex* 420.60.

Research Station Kentville, Nova Scotia

PROFESSIONAL STAFF

Administration

J. R. WRIGHT, B.Sc. (Agr.), M.S., Ph.D., F.C.I.C.	Director
K. M. CARTER, B.Comm.	Administrative Officer
E. M. TINGLE (Miss), B.Sc., M.Sc., M.L.S.	Librarian

Berry Crops and Ornamentals

D. L. CRAIG, B.Sc. (Agr.), M.S., Ph.D.	Head of Section; Plant breeding
L. E. AALDERS, B.Sc., M.Sc., Ph.D.	Cytology and genetics
C. R. BLATT, B.Sc., M.S., Ph.D.	Plant nutrition
I. V. HALL, B.Sc., M.Sc., Ph.D.	Ecology and physiology

Entomology

A. W. MACPHEE, B.Sc. (Agr.), M.Sc., Ph.D.	Head of Section; Insect ecology
K. P. BUTLER, B.A.	Insect ecology—life systems
H. J. HERBERT (Miss), B.Sc. (Agr.)	Mite investigations
C. R. MACLELLAN, M.C., B.Sc. (Agr.), M.A.	Ecology of the codling moth
W. T. A. NEILSON, B.Sc., M.Sc.	Apple maggot
D. J. PREE, B.S.A., M.Sc., Ph.D.	Toxicology
K. H. SANFORD, B.Sc. (Agr.), M.Sc.	Development of integrated programs
H. B. SPECHT, B.Sc. (Agr.), M.S., Ph.D.	Vegetable insects

Food Technology

R. STARK, B.Sc., Ph.D.	Head of Section; Food processing
D. J. SCHRODER, B.Sc. (Agr.), M.Sc., Ph.D.	Food microbiology
W. G. SIMPSON, B.S.A., M.S.	Product development

Plant Pathology and Pesticide Residues

R. G. ROSS, D.F.C., B.Sc. (Agr.), M.Sc., Ph.D.	Head of Section; Tree fruit diseases
D. CHISHOLM, B.Sc.	Insecticide chemistry
C. O. GOURLEY, B.Sc. (Agr.)	Vegetable and berry diseases
C. L. LOCKHART, B.Sc. (Agr.), M.Sc.	Fruit and vegetable storage diseases
M. T. H. RAGAB, B.S., M.S., Ph.D.	Herbicide chemistry
D. K. R. STEWART, B.Sc., B.A., M.Sc., Ph.D.	Fungicide chemistry

Plant Physiology

F. R. FORSYTH, B.A., Ph.D.	Head of Section; Postharvest physiology
P. A. POAPST, B.Sc., B.Sc. (Agr.)	Postharvest physiology
D. H. WEBSTER, B.Sc., M.Sc., Ph.D.	Tree fruit physiology

Poultry

F. G. PROUDFOOT, B.Sc. (Agr.), M.S.	Head of Section; Genetics
A. C. COX, B.S.A., M.Sc., Ph.D.	Nutritional physiology

Tree Fruits

A. D. CROWE, B.Sc. (Agr.), M.Sc., Ph.D.	Head of Section; Tree fruit breeding
---	--------------------------------------

Vegetables, Cereals, and Field Crops

R. F. BISHOP, B.Sc., M.Sc., Ph.D.	Head of Section; Soil fertility
E. W. CHIPMAN, B.Sc. (Agr.)	Vegetable crops
C. R. MACEachern, B.Sc.	Soil chemistry
G. G. SMELTZER, B.Sc. (Agr.)	Cereals and field crops
L. R. TOWNSEND, B.A., B.Sc.	Plant chemistry

Experimental Farm, Nappan

T. M. MACINTYRE, B.Sc. (Agr.), M.Sc.	Superintendent; Livestock management and nutrition
F. W. CALDER, B.Sc. (Agr.), M.S.	Forage crops, pasture
L. P. JACKSON, B.Sc. (Agr.), M.S.	Soils—crop nutrition
J. E. LANGILLE, B.Sc. (Agr.)	Cereals and forage crops

Departure

J. S. LEEFE, B.S.A. Retired November 2, 1973	Assistant Director; Weed control
---	----------------------------------

INTRODUCTION

This publication is a summary of the main research results for 1973 of the Research Station at Kentville and the associated Experimental Farm at Nappan. Kentville is the center for research in horticulture, poultry, food technology, and pesticide residues in the Atlantic Provinces. The Experimental Farm at Nappan, 80 km (50 miles) to the north, serves as an associate establishment doing applied and developmental research on the production of cereals, forages, and lowbush blueberries, and on the management of livestock. The Atlantic region is characterized by a cool humid climate and Podzol soils.

On November 2, Mr. J. S. Leefe, Assistant Director, retired after 39 years of administration and research on weed control in horticultural crops. On March 27, Dr. D. J. Schroder, a microbiologist, joined the Food Technology Section of the Station.

Copies of this chapter of the Research Branch Report and reprints of the listed publications are available on request from Research Station, Research Branch, Agriculture Canada, Kentville, N.S. B4N 1J5.

J. R. Wright
Director

BREEDING, NUTRITION, AND CULTURE OF CROPS

Lowbush Blueberries and Cranberries

Growth pattern. When loops were tied in the shoots of lowbush blueberry plants placed in a normal upright position, the region of origin of new bud development was markedly affected. The number and total length of new shoots in the loop were significantly greater than in the same area of upright plants without a loop. Nonlooped plants had slightly more growth above the position of the loop and immediately below it. There was relatively little difference in growth at any of the positions when looped and nonlooped plants were held in a reclining position. Although reclining plants had adequate moisture and the same nutrient levels, they grew less than plants in a vertical position. These findings indicate that growth of the lowbush blueberry, a woody shrub, under a gravimetric force, follows very closely the pattern previously found in woody trees.

Biology of sheep-laurel. Two important weeds were written up for a new series of papers on the biology of Canadian weeds. Sheep-laurel occurs as a woody shrub in pastures and lowbush blueberry fields of Eastern Canada. It occupies valuable space in pastures, but it is an even more serious problem as a source of livestock poisoning. When food is scarce during the colder months or drier seasons, domestic animals,

especially sheep, graze on the leaves with lethal effects. Sheep-laurel reproduces from seeds, but once established it spreads laterally by underground stems. Burning of the aboveground stems hastens the growth below ground by initiating growth from dormant buds. 2,4-D and dicamba were found to reduce the stand of sheep-laurel, at an estimated cost of \$15 to \$17/ha.

Biology of broad-leaved meadowsweet. Broad-leaved meadowsweet is another woody shrub that occurs in poorly drained areas of pastures, blueberry fields, and cranberry bogs of Eastern Canada. Hand-pulling or digging is the accepted method of control in cranberry stands, as cranberry vines are very susceptible to 2,4-D and this weed is quite resistant. Broad-leaved meadowsweet reproduces from seeds which germinate readily; germination is 87% under favorable conditions.

Highbush Blueberries

Management. In a 6-yr field study with highbush blueberries, the incorporation of raw sawdust or peat with the soil, plus surface-applied fertilizer, did not increase yields, bush size, or vigor. Control bushes were more vigorous, produced higher yields with larger fruit, and usually had lower levels of all nutrients, Ca excepted, than those receiving the other treatments. However, the differences were not generally significant at the 5% level. Regression equations revealed that leaf Ca, bush size, and winter injury

were the most important variables associated with yields, whereas fruit size was most closely related to leaf Ca, Mg, and N.

Strawberries

Management. A study was done to determine if it was worthwhile to harvest fruits in the year of planting. Additional factors studied were the effect of planting date on the time of fruit maturity in the planting year, the vigor of the plant stand at the end of the planting year, and the yield the next year. Fruit yields of strawberry cultivars in the planting year were not large enough to warrant picking. The number of days to fruit maturity in the planting year decreased with each delay in planting date. Second-year yields were markedly affected by planting date, maximum yields being obtained from strawberries planted between mid-May and mid-June. For two years, 1970 and 1971, number of runners and total yield were correlated, whereas fruit size and yield were correlated only in 1971.

Hormone treatments to increase runners. In two greenhouse experiments and one field trial, ethephon [2-(chloroethyl)phosphonic acid; Ethrel, Amchem Products Inc.] applied at 480, 960, or 1,920 ppm to the strawberry cultivar Redcoat increased the number of runner plants. In the greenhouse, application of ethephon at 960 and 1,920 ppm significantly increased the numbers of runner plants from fruited plants above those from deflowered (control) plants. Ethephon treatments increased the percentage of the total crop harvested in the first four pickings by an average of 44% above the control. In the field trial, plants allowed to flower and fruit received ethephon at 960 ppm and produced runner plant numbers similar to those of the deflowered plants.

Raspberries

Hormone treatments to increase hardiness. Winter injury to raspberry canes is the main factor that limits production in Nova Scotia. Since applications of SADH (succinic acid-2,2-dimethylhydrazide) have improved plant hardiness in other crops, it was considered worthy of trial under our conditions. SADH sprays were applied at 1,000 and 2,000 ppm to the red raspberry cultivars Trent and Canby on four dates during the 1970 and 1971 growing seasons. The sprays did not affect bud survival, yield, or number of

flowers per lateral. Inconsistent reductions occurred in berry weight, number of flowering laterals, buds per cane, and cane diameter. In all instances, cane height was reduced.

Ornamentals

Four rhododendron cultivars were named and released because they were hardy at Kentville, were of good plant type, and had attractive flowers or inflorescences. The cultivars were named Acadia, Evangeline, Gabriel, and Grand Pré.

Apples

Foliar absorption. Addition of $\text{Ca}(\text{NO}_3)_2$ to sprays of MgSO_4 increased absorption of Mg from 23.7% to 52.8% by McIntosh apple leaves. Addition of urea had no effect. Absorption of Mg over 24 h from a solution of MgSO_4 varied from -2.5% to 19.4% of the initial spray deposit, and the quantity absorbed was significant in only one of five spray treatments. Absorption from a solution of $\text{Mg}(\text{NO}_3)_2$ varied from 18.3% to 50.2% and the quantity absorbed was significant in all spray treatments. Most of the variation in absorption could be explained by humidity and temperature conditions during the period of absorption.

Vegetable Crops

Moisture levels from rhubarb. Forced rhubarb petioles grown from roots maintained at a moisture level of 40–45% had higher dry matter, soluble solids, and acidity, and produced a sauce of more attractive color than did petioles from roots maintained at 80–90% moisture. Yields did not differ.

Nutrient requirements of celery and lettuce on peat. Celery and head lettuce were grown on sphagnum peat and received various fertilizer treatments with N, P, and K. Each nutrient was applied at four rates in combination with constant rates of the other two.

Results indicated that requirements of the two crops for N were similar but that celery required higher rates of P and K than lettuce. For the latter crop, N, P, and K at approximately 180, 40, and 150 kg/ha respectively appeared adequate, whereas the P and K requirements of celery were 80 and at least 225 kg/ha.

Nutrient requirements of carrots on peat and mineral soils. Carrots were grown on both sphagnum peat and mineral soils from 1969 to 1972 inclusive. Fertilizer treatments

consisted of three rates of N, of P, and of K applied in all possible combinations.

In almost every instance rates of N, P, and K applied to sphagnum peat were reflected in the levels of these nutrients found in carrot leaves. This was not the case with mineral soils. On sphagnum peat there were eight opportunities, and on mineral soils seven, for each of the three applied nutrients to influence yields. On peat, N increased yields in three instances, P in one, and K in five. On mineral soils, N decreased yields in two instances, P decreased them in one and increased them in one, whereas K had no effect.

The results suggest that on sphagnum peat carrots may require N, P, and K at up to 250, 50, and 150 kg/ha respectively, whereas on mineral soils maximum rates would be 25, 25, and 50 kg/ha.

Forage Crops

Hormone increases hardiness. The chemical Alar-85 (UniRoyal Chemical) was applied to alfalfa and Ladino white clover plants as an aqueous spray in a range from 0 to 15,000 ppm. It was found that Alar-85 altered the growth of the plants and improved their hardiness in conditions of frost and drought. Application also resulted in changes in the carbohydrate content of the plant tissue, as well as changes in leaf structure and the morphology of vascular tissue. Spectrophotometric determinations of extracts of plant tissue indicated increased photosynthetic pigments with increased treatment.

Alfalfa management. The effects of early summer and fall cutting management systems on two alfalfa cultivars were studied over a 3-yr period. Removal of the first crop of cultivars Saranac and Narragansett at prebud stage, followed by two cuts at the early-bloom stage before early September and a late-fall harvest on October 25, produced seasonal dry matter (DM) yields of 7.5–8.6 t/ha in the 1st yr. Stand deterioration, however, was severe and by the 3rd yr, practically all alfalfa had disappeared. Average crude protein (CP) in cut 1 was 17.7–21.9% and in vitro digestibility of dry matter (IVD) was 67.4–73.8%.

Removal of the first cut at bud stage with two subsequent harvests at the early-bloom stage also allowed a total of three harvests before early September and resulted in

seasonal DM yields of 8.6–8.8 t/ha in the 1st yr. Although the survival of alfalfa was higher than under the management systems where cut 1 was at prebud stage, a considerable decrease of alfalfa was still observed in the 3rd yr. Under this management, the average CP in cut 1 was 15.8–16.3% and IVD was 64.1–68.4%.

Harvesting the first crop at early-bloom to midbloom stage and the second crop at early bloom in early to mid-August, followed by third harvest in late October, resulted in good survival with seasonal DM yields of 6.1–10.6 t/ha. Lower CP and IVD were recorded for cut 1 than under the more intensive management systems.

Under all managements, average CP in cuts 2 and 3 was 14.9–17.3% and 13.3–19.4%; IVD was 54.5–60.7% in cut 2 and 56.0–64.4% in cut 3.

Nutrients for barley. Two barley cultivars, Charlottetown 80 and Herta, were grown on plots of Tormentine sandy loam soil that had been limed to a range of pH levels (4.8, 5.1, 5.8, 6.6, and 7.1) for 10 yr prior to this experiment. Each pH area was subdivided to provide a factorial arrangement of N fertilizer at 30, 60, 90, and 120 kg/ha with P–K fertilizer at 10–19, 30–56, 59–112, and 88–168 kg/ha. Yield of each cultivar increased when the soil pH was increased from 4.8 to 5.8. The cultivar Charlottetown exceeded Herta in yield at the low pH levels. The greatest responses from N fertilizer were at the 60- and 90-kg rates in combination with P–K at 59–112 and 88–168 kg/ha, for the mean of the two cultivars. Percentages of N in barley tissue varied with pH and decreased with increasing rates of P–K fertilization. Percentages of total N and protein nitrogen in barley grain increased as the pH increased. Percentages of P and K in tissue also increased as the pH increased. The IVD of barley grain was not affected by P–K but decreased slightly as N fertilization increased.

Management of three grasses. The primary growth of Climax timothy, Saratoga brome-grass, and Frode orchardgrass was harvested at eight stages of development and aftermath, after a 40- to 64-day regrowth interval over a 3-yr period.

Total DM yields of primary growth increased up to early flowering and ranged from 4,370 to 11,840 kg/ha, depending on

grass species, cutting management, and season. Aftermath rarely exceeded 3,500 kg DM/ha. The stage of development at first harvest had only a limited influence on aftermath production. Within the season, orchardgrass had a more uniform yield distribution than timothy or brome-grass. The yield distribution of the three grasses was most uniform where the first harvest was taken at the immature stages of development. The stand persistence was satisfactory under all cutting management systems.

The IVD of primary growth ranged from 76.5 to 37.0%. In the 2nd and 3rd yr, decline in IVD of primary growth averaged 0.69, 0.66, and 0.82% per day for timothy, brome-grass, and orchardgrass, respectively, over a 24-day period. In the 1st yr this decline was somewhat higher. The IVD of aftermath tended to be higher where the regrowth period was shortest, although this was inconsistent. Total digestible DM yields increased up to heading stage in the 2nd and 3rd yr.

The CP of primary growth ranged from 18.0 to 7.1% under various cutting systems and decreased at an average daily rate of 0.33 to 0.37%. The CP of aftermath ranged from 15.0 to 9.6%. Longer regrowth periods resulted in lower percentages of CP. Average seasonal CP yields varied little due to cutting management and were highest for orchardgrass.

Fababean evaluation. Sixteen cultivars of fababeans were evaluated at five locations in the Atlantic Provinces in 1973. This work, coordinated from Nappan, introduced some new early cultivars that were better adapted to the region and more productive than Maris Bead, which is now being grown. Disease resistance of new cultivars to *Botrytis fabae* Sard. and *Ascochyta fabae* Speg. would be an asset. Protein content is very important as most cultivars contain 27 to 29% protein. Seeding of fababeans in 1973 began on March 30 and continued at weekly intervals until June 4. A number of methods of seeding were tried; rototilling of broadcast seed into the ground on April 10 was the most productive. Seeding after June 1 in the Nappan area appears to be too late.

Field pea evaluation. Field pea plantings are increasing annually in the Atlantic Provinces because this crop is a good source of protein for livestock. Twenty-two cultivars and strains were evaluated at Nappan in 1973. Yields were not as high in 1973 as in

1972 because the growing season was very wet. Root rot was evident in an area where peas or beans had not been grown previously. Protein content as well as yield is important, as most cultivars contain approximately 23% protein.

Soils

Effects of limestone on dikeland soils. The long-term effects of limestone on physical properties of dikeland soil showed that various rates of limestone from 0 to 5.6 t/ha applied at regular intervals of time resulted in pH values from 4.76 to 6.90, increased yields of oats and grass, increased quantities of 10-mesh aggregates, increased moisture retention values, decreased rates of percolation, decreased capillary porosities, increased noncapillary values, and increased bulk density values.

Fertilizer treatments for hay on three soil types. Three soil types, Pugwash sandy clay loam, Woodburn gravelly loam, and Kirkhill silt loam, were compared by determining response of crops to fertilizer treatments. The crops completed two cycles of a 4-yr rotation consisting of 1 yr of oats and 3 yr of a grass-legume mixture for hay production. A rotation was started each year on a new section of the experimental site during the first rotation, so that all crops were being grown in any one year. Treatments were: N at 0, 56, and 112 kg/ha for the first rotation, and 0, 168, and 336 kg/ha for the second rotation; P at 0, 37, and 74 kg/ha for the first rotation, and 0, 110 and 220 kg/ha for the second rotation; and K at 0, 56, and 112 kg/ha for the first rotation, and 0, 209, and 418 kg/ha for the second rotation. Manure was applied at 0 and 22 t/ha.

There was a significant difference in yield on the three soil types for 1st-, 2nd-, and 3rd-yr hay crops. Manure increased the yield of all hay crops on all three soils, and oat yields on Woodburn and Kirkhill soils. There were varying responses to rates of application of individual nutrients on different soil types. Percentages of species in the hay stands varied among soil types and among years.

Dikeland management. The Research Branch and a private landowner have cooperated in a 5-yr plan for the improvement of 20 ha (50 ac) of dikeland. This program was started in 1967 and most of the work was completed in 1972. The final leveling and seeding were done in 1973. As a result of this

study, much has been learned about surface formation, drainage, fertilization, and the proper seeding of a suitable crop. Special machines such as a large-scale land leveler were successfully utilized. The techniques used in this study have been adopted by farmers for land development in other dikeland areas of the region.

PROTECTION OF CROPS AGAINST PESTS

Plant Pathology

Cranberry quality. Through the cooperation of a grower in Nova Scotia, complete records on cranberry production from two bogs were examined. Over a 4-yr period, 1969–72, the percentage of green berries at harvest ranged from 1.9 to 5.7, small berries from 1.4 to 4.3, and decay from 1.2 to 16.3.

Apple diseases. Apple leaves, collected at intervals of 1 and 3 mo after trees had received seasonal sprays of benomyl and thiophanate-methyl, and sterilized in propylene oxide, would not produce perithecia of *Venturia inaequalis* (Cke.) Wint. Leaves overwintered outdoors from these trees also did not produce perithecia. In synthetic culture media, conidium production of different isolates and races of *V. inaequalis* varied significantly but was not affected by varying the concentration of conidia used as inoculum and the age of cultures from which the inoculum was derived. Making single conidium transfers every 6 mo did not consistently enhance conidium formation. Conidium yields were optimum between 16 and 19 days at a temperature of 16°C. The concentrations of glucose, nitrogen, KH_2PO_4 , and MgSO_4 required for optimum conidium production were not critical.

In a bioassay for the presence of "replant disease," Beautiful Arcade apple seedlings planted in pots grew significantly better in most apple orchard soils fumigated with chloropicrin than in untreated soil. The cause of the poor growth of apple trees in replanted orchards in Nova Scotia is not known.

Crown rot of apple trees caused by *Phytophthora cactorum* (Leb. & Cohn) Schroet. was reported for the first time in Nova Scotia. The extent of the disease is not known but the fungus is widespread in orchard soils. *Penicillium expansum* Link ex S. F. Gray

produced cankers on apple seedlings and detached twigs. *Fusarium oxysporum* Schlecht. caused cankers on the latter.

Diseases of other crops. Preharvest sprays of thiabendazole and wax (Folicote; Sun Oil Co., Philadelphia) on red raspberries gave significant control of gray mold rot caused by *Botrytis cinerea* Pers. when berries were held for 1 day at 4.4°C and 1 day at 18.3°C. Yields were increased slightly and in some instances berries were firmer.

Alternaria rot, developing from black leaf spot infections caused by *Alternaria brassicicola* (Schw.) Wiltshire, has become a problem in cabbage stored at high humidities in jacketed cold storage. A spray of mancozeb 1 day before harvest was just as effective as a weekly field spray program in preventing development of the rot on stored cabbage.

Alternaria alternata (Fr.) Keissler was a problem on cold-stored Clapp Favorite pears in 1972–73 storage season. Controlled-atmosphere storage provided some control of the organism.

Thiabendazole and benomyl gave excellent control of gray mold rot, from *Botrytis cinerea* Pers., on stored carrots.

Results of surveys for 1971 and 1972 showed green petal disease of strawberries was less than 1% in both years. This low level suggests that the virus disease is not of major importance in the cultivars used for commercial production. Inconclusive results were obtained from tests with systemic insecticides, either incorporated into the soil or sprayed on the plants, for control of the leafhopper vectors of green petal disease.

Chocolate spot, *Botrytis fabae* Sard., and leaf and pod spot, *Ascochyta fabae* Speg., were found in Nova Scotia on plants of *Vicia faba* L. var. *minor* (Peterm.) Beck, fababean cultivar Maris Bead, for the first time in August 1970. *B. fabae* has not been reported before now in North America. It occurred mainly on the foliage and had no apparent effect on yield of spring-grown beans. The effect of *A. fabae* was most severe on the seed, and it may be the greater threat to bean production.

Insect Pests

Cutworms. Cutworms on a number of crops have been reduced by increased knowledge of identification, biology, and chemical controls. Twice as many larvae of the darksided cutworm, *Euxoa messoria*

(Harr.), were found in plots of a tobacco field fall-planted with rye as in plots winterfallowed. The number of plants injured was correlated with the number of larvae found. Larvae of the variegated cutworm, *Peridroma saucia* (Hbn.), appeared 2 to 4 wk later than those of the darksided cutworm and winter cultural methods had little effect on their numbers.

Strawberry insects. A reassessment has been made of the control of the strawberry weevil and plant bugs, which have caused appreciable losses in some strawberry plantations. The restrictions on use and availability of DDT have emphasized the need for control, and tests in 1973 provided data for improving control recommendations. Several plant bug species are involved. Aphid control is being studied on strawberry in relation to virus transmission, and on raspberry in relation to host resistance.

Codling moth. Monitoring populations of the codling moth with sex pheromone traps was very successful in 1972 and 1973. Using guide rules determined under a variety of conditions, growers were able to use trap data for better timing of insecticides and reduced dosages and numbers of applications. In a number of instances chemical control was unnecessary. In an experimental, insecticide-free orchard, extensive trapping reduced codling moth damage for the second consecutive year. Although insufficient data are available to pinpoint the cause for the decrease, the traps, at least, are an additional control measure.

Apple maggot. Dimethoate was the most toxic of 28 insecticides tested in the laboratory against adult apple-maggot flies. In small-scale field tests, dimethoate protected fruit from adults for over 14 days and was approximately twice as effective as azinphos-methyl. A juvenile-hormone analogue (XR515) applied to third-instar larvae prevented development to the adult stage. Probably an application to the soil would control larvae as they leave the fruit; however, the high dosage required may be impractical.

Studies on maggot during the past 6 yr showed that the amount and proportion of apple varieties were major factors in population changes. Early or mid-season varieties generally produced increases. Under favorable conditions, populations reached near

maximum levels in 5 yr. Where varieties were marginal hosts to maggot and crop volume was variable, maggot populations were erratic. A factor associated with adult fecundity in one experimental orchard had a marked influence, causing a decrease in numbers in 1973.

Wireworms. A recent study of the larva of *Agriotes sputator* (L.), a wireworm, showed that this species preferred grasses to several weed species. *Agriotes obscurus* (L.) was found to feed selectively on grasses and clovers.

Apple moth. The results of studies conducted in Australia by a staff member on the light brown apple moth, *Epiphyas postvittana* (Walker), have been published and cover in detail the hosts and destructiveness of this species, which is not found in North America. It poses a possible threat to this area.

Red mite. A study on populations of the European red mite, *Panonychus ulmi* (Koch), was conducted in a mature apple orchard in Nova Scotia. By a random selection and a standard selection technique, the density of eggs over the whole tree was compared with the density on a selected area, such as those parts of the tree lower than breast height and within 1 m of the periphery. Both methods provided nearly equivalent estimates of population densities for generations 2 and 4 but not for generation 3. The population estimates based on sampling from the selected area gave an overestimation of the whole tree population.

Pesticide Residues

Endosulfan. Total residues of the insecticide endosulfan (α and β isomers) plus the metabolite endosulfan sulfate were very persistent in a sandy loam soil during a 2½-yr period. The α -endosulfan was converted almost completely within a few months to endosulfan sulfate, the concentration of which remained constant during the experiment. The amount of β -endosulfan decreased very slowly. Potatoes grown in soil treated with endosulfan at 6.7 kg/ha (6 lb/ac) active ingredient contained 0.07 ppm endosulfan sulfate. Eight foliar sprays resulted in negligible residues in tubers.

Chlordane. The insecticide chlordane was very persistent in two sandy loam soils over a 2-yr period when incorporated at a rate of

6.7 kg/ha (6 lb/ac) active ingredient. Maximum residues found in beets, potatoes, rutabagas, carrots, and parsnips grown in these soils were 0.03, 0.04, 0.01, 0.26, and 0.24 ppm chlordane.

STORAGE

Cranberries

Because of the current interest in controlled-atmosphere storage for cranberries, the rates of diffusion of CO₂, O₂ and ethylene in cranberry fruit were determined. Outward diffusion of CO₂ from the cultivar Stevens and from native seedling cranberries, *Vaccinium macrocarpon* Ait., collected in 1971 and held for 6 mo at 3°C, proceeded at the rate of 4.55 and 2.56 $\mu\text{l}/\text{cm}^2$ per h, respectively. The rates of movement of O₂ into Stevens and into a native seedling were 2.64 and 3.28 $\mu\text{l}/\text{cm}^2$ per h. For cranberries collected in 1972 and held for 1 mo at 3°C, the respective values for CO₂ were 1.48 and 1.53 $\mu\text{l}/\text{cm}^2$ per h, and for O₂ they were 3.09 and 3.65 $\mu\text{l}/\text{cm}^2$ per h.

Potatoes

An aqueous emulsion of Tween 85 (4–5%), Tween 60 (10–15%), or corn oil (10–15%) applied with the aid of Tween 60 (3–4%) controlled greening in tubers of several potato cultivars. The tubers were sprayed to runoff upon removal from 5°C dark storage and were subsequently retained in light at elevated temperatures for 13 or more days. When peel from treated and control tubers was removed and exposed to similar conditions of light and temperature, the two peels produced similar amounts of chlorophyll. When peel was removed from control tubers and subjected to high (40%) concentrations of CO₂ and normal concentrations of O₂, the production of chlorophyll was substantially inhibited.

When tubers treated with Tween 85 were exposed to temperatures above 5°C, the respiration rate increased slowly and reached higher levels that persisted for a longer time than was the case for the controls. It was further observed that the internal concentration of CO₂ increased and O₂ decreased. The changes in internal gas concentrations varied directly with the concentration of applied surfactant. Tween 85 was found to control

greening when the internal CO₂ concentration exceeded 15% within 5 days of treatment.

It appears that the role of Tween 85, Tween 60, and corn oil in the control of greening is one of raising the internal CO₂ levels in the epidermal tissues to inhibitory concentrations. It is speculated that this effect is possibly supplemented by concomitant reductions in O₂.

Tomatoes

Approximately 453 g (1 lb) of mature green tomatoes, sealed in a 1-mil polyethylene plastic bag and kept at 10.0–11.7°C (50–53°F), can be stored for at least 8 wk. Carbon dioxide levels are around 2–3% and oxygen levels around 5–7% in this controlled-atmosphere package. Whenever the plastic is opened and the tomatoes are ripened at 18.3°C (65°F), a total loss of less than 20% from rots can be expected, whereas control samples show 98% loss after an 8-wk period of storage. Tomatoes from vines well protected by fungicides can be expected to give the best results.

Pears

Higher-quality fruits of Clapp Favorite and Bartlett pears with much less internal breakdown were obtained when they were stored at –1.1°C (30°F) in low oxygen – carbon dioxide atmospheres than when stored in air. Clapp Favorite pears required approximately zero carbon dioxide with 2% oxygen, whereas Bartlett pears stored best with 2% carbon dioxide and 2% oxygen.

After about 6 wk of cold storage in air, the Bartlett pears did not ripen but remained firm after exposure to 18.3°C (65°F) for 1 wk. The controlled-atmosphere storage overcame this problem and pears stored for 24 wk in a controlled atmosphere subsequently ripened satisfactorily.

The Clapp Favorite pears showed serious levels of carbon dioxide injury (collapsed cells and cavities) in 2% carbon dioxide and 2% oxygen. This cultivar is therefore highly sensitive to carbon dioxide injury, which can be avoided only by using essentially zero carbon dioxide.

Cranberry Sauce

Sauce made from cranberries stored for 14 mo at 3.3°C under both low (65–70%) and high (95–100%) relative humidity in 100% N₂ was of good flavor. Flavor ratings indicated that sauce from berries stored in N₂ was of superior flavor to sauce prepared from frozen berries after a similar storage period. The major aroma constituents detected were acetaldehyde, methyl acetate, and ethyl alcohol. There was less decay in cranberries stored in conditions of low than high humidity.

Storage of Green Tomatoes for Pickling

Green tomatoes stored in 0.25% SO₂ brine in wooden barrels from 2 to 38 wk or in 0.13% SO₂ for 10 wk were suitable for making chow-chow after a 1.5-h rinse in tap water. For long-term storage in 0.25% SO₂ brine, green tomatoes were held at 11.1°C or outdoors. No adverse effects were found from freezing weather provided the barrels were insulated with 12.5 cm (5 in.) of fiber glass or 7.5 cm (3 in.) of sprayed-on polyurethane foam. Taste panels rated the chow-chow similar in appearance, color, and flavor to that of chow-chow commercially prepared from freshly harvested green tomatoes. Commercial tests suggested that the storage life may be extended to 1 yr.

Quality of French Fries

Frozen French fries are popular for both domestic and institutional use, and reliable measurement of the qualities of this product has become increasingly important in both research and quality control. An instrument has been developed that measures differences in limpness among French fries of different specific gravities. The results are affected by cooking time, time after cooking, and the speed of deflection of the fries. These parameters must, therefore, be controlled to allow meaningful comparisons. Plots of the data indicated a definite relationship between limpness as determined by this instrument and limpness as determined by sensory tests.

Poultry

Management. Two experiments, involving 2,400 broilers, were conducted to evaluate the feasibility of rearing broilers on a heated, litterless floor compared with rearing broilers under a conventional brooder with planer shavings over a concrete floor. Results provide evidence that it is feasible to use a hot-water-heated floor with either iron or plastic pipe to provide heat for growing broilers, without the use of litter materials.

Two other experiments were conducted to evaluate the effects of six different dietary treatments during parental rearing and a single generation of divergent selection for 8-wk sire weight on the broiler progeny of two commercial parental genotypes. Results provide evidence that, despite a wide variation in feed treatments during parental rearing, there was no significant effect on broiler performance. Data from these experiments support the contention that a practical gain in broiler performance may be expected when a single generation of sire selection for 8-wk body weight is practiced.

The effects on broiler performance of different floor, waterer, feeder-space, and light treatments were estimated. Increased bird density resulted in a reduction in body weight, poorer feed conversion, reduced carcass quality, and lower monetary returns per bird started. Effects of feeder space were inconsistent. Waterer spaces examined had little effect on bird performance. Light treatments studied revealed that cycles of 1 h of light with 3 h of darkness resulted in slightly better feed conversion than cycles of 3 h of light and 1 h of darkness.

Feeding of grit. An experiment was conducted to evaluate feeding various quantities of grit compared with no grit to Leghorns reared in confinement without access to grit and housed in cages. The different levels of grit fed resulted in no beneficial effect for the traits: egg production, mortality, feed efficiency, body weight, Haugh-unit scores, specific gravity of eggs, or egg weight. Birds were fed all-mash diets during the rearing and laying periods.

Packaging of eggs. Traditionally, table eggs have been packed in the small-end-down position. Experiments were designed to compare the Haugh-unit scores of eggs

stored in two positions for 8 and 15 days. The data revealed that there were no significant differences between eggs held in the small-end-up and the small-end-down orientation when eggs were stored for either 8 or 15 days.

Sheep

Dosing with seaweed. Shropshire ewes, aged 4 to 9 yr, were dosed once weekly with Irish moss, *Chondrus crispus* (L.) Stackh., grown in large tanks in a greenhouse. The seaweed was fed by an esophageal tube within 4 h of harvest from the tanks. After 4 wk, the ewes were tupped, and the dosing

continued until 1 wk before parturition. Nineteen lambs were obtained from 12 dosed ewes and 15 lambs from 12 controls. The mean loss in weight of the dosed ewes in the 4 wk after parturition was 0.50 kg/day and the corresponding loss by the controls was 0.45 kg/day. In the same period, the mean daily weight gain of lambs was 0.25 kg for the singles from both groups, 0.18 kg for the twins from the dosed sheep, and 0.21 kg for the twins from the controls. At shearing the dosed ewes gave a mean fleece weight of 3.09 kg, whereas the control groups had an average fleece weight of 3.48 kg. It is concluded that, at the dose level used, *C. crispus* was not acutely toxic.

PUBLICATIONS

Research

Basu, P. K., Crete, R., Donaldson, A. G., Gourley, C. O., Haas, J. H., Harper, F. R., Lawrence, C. H., Seaman, W. L., Toms, H. N. W., Wong, S. I., and Zimmer, R. C. 1973. Prevalence and severity of diseases of processing peas in Canada, 1970-71. *Can. Plant Dis. Surv.* 53:49-57.

Bishop, R. F., Chipman, E. W., and MacEachern, C. R. 1973. Effect of nitrogen, phosphorus and potassium on yields and nutrient levels in celery and head lettuce grown on sphagnum peat. *Commun. Soil Sci. & Plant Anal.* 4:375-387.

Bishop, R. F., and MacEachern, C. R. 1973. The zinc status of some Nova Scotia soils and crops. *Commun. Soil Sci. & Plant Anal.* 4:41-50.

Blatt, C. R. 1973. Effect of superphosphate applications on soil phosphorus and on crop phosphorus removal by the strawberry. *Commun. Soil Sci. & Plant Anal.* 4:245-250.

Blatt, C. R., and Sponagle, A. G. 1973. Effects of 2-chloroethylphosphonic acid on runner plant yields and fruit maturity of the strawberry. *Can. J. Plant Sci.* 53:585-587.

Calder, F. W., Canham, W. D., and Fensom, D. S. 1973. Some effects of Alar-85 on the physiology of alfalfa and Ladino clover. *Can. J. Plant Sci.* 53:269-278.

Calder, F. W., and MacLeod, L. B. 1973. Fertility studies in relation to soil type. *J. Agric. Sci., Camb.* 81:165-171.

Chipman, E. W., and Stark, R. 1973. Forced rhubarb quality affected by soil moisture levels in forcing shed. *Can. J. Plant Sci.* 53:331-333.

Chiykowski, L. N., Colpitts, S. R., Coulombe, L. J., Delbridge, R. W., Gourley, C. O., Lawrence, C. H., Murray, R. A., Santerre, J., and Thompson, L. S. 1973. Strawberry green petal disease in Quebec and the Maritime Provinces, 1971-72. *Can. Plant Dis. Surv.* 53:63-66.

Craig, D. L. 1973. Acadia, Evangeline, Gabriel, and Grand Pré rhododendrons. *Can. J. Plant Sci.* 53:355.

Craig, D. L., and Aalders, L. E. 1973. Response of 'Trent' and 'Canby' red raspberry to SADH applications. *HortScience* 8:313.

Craig, D. L., Aalders, L. E., and Leefe, J. S. 1973. Effects of planting date on strawberry yield in the planting year, days to fruit maturity, plant stand, and second-year yields. *Can. J. Plant Sci.* 53:559-563.

Eaves, C. A. 1973. Environmental control in the storage of temperate fruits. *Proc. 18th Int. Hortic. Congr.* 4:133-142.

Forsyth, F. R., Hall, I. V., and Lightfoot, H. J. 1973. Diffusion of CO₂, O₂, and ethylene in cranberry fruit. *HortScience* 8:45-46.

Fox, C. J. S. 1973. Some feeding responses of a wireworm, *Agriotes sputator* (L.), (Coleoptera: Elateridae). *Phytoprotection* 54:43-45.

Fox, C. J. S. 1973. Influence of vegetation on the distribution of wireworms in grassland: Observations on *Agriotes obscurus* (L.) (Col.: Elateridae). *Phytoprotection* 54:69-71.

- Gourley, C. O., and Delbridge, R. W. 1973. *Botrytis fabae* and *Ascochyta fabae* on broad beans in Nova Scotia. Can. Plant Dis. Surv. 53:79-82.
- Herbert, H. J., and Butler, K. P. 1973. Distribution of phytophagous and predacious mites on apple trees in Nova Scotia. Can. Entomol. 105:271-276.
- Herbert, H. J., and Butler, K. P. 1973. The effect of European red mite, *Panonychus ulmi* (Acarina: Tetranychidae), infestations on N, P, and K concentrations in apple foliage throughout the season. Can. Entomol. 105:263-269.
- Jackson, L. P., Aalders, L. E., and Hall, I. V. 1972. Berry size and seed number in commercial lowbush blueberry fields of Nova Scotia. Nat. Can. 99:615-619.
- Lockhart, C. L., Hall, I. V., and Murray, R. A. 1973. Losses and yields of cranberries from bogs in Nova Scotia from 1969-72. Can. Plant Dis. Surv. 53:99-100.
- Lockhart, C. L., and Stark, R. 1973. Storing green tomatoes in SO₂ brine for chow-chow. Can. Inst. Food Sci. & Technol. J. 6:216-218.
- MacLellan, C. R. 1973. Natural enemies of the light brown apple moth, *Epiphyas postvittana*, in the Australian capital territory. Can. Entomol. 105:681-700.
- MacLeod, L. B., Kunelius, H. T., and Calder, F. W. 1972. Effects of early summer and fall cutting management on dry matter yields, digestibility, crude protein, and survival of Saranac and Narragansett alfalfas. Can. J. Plant Sci. 52:941-948.
- Neilson, W. T. A. 1973. Improved method for rearing apple maggot larvae on artificial media. J. Econ. Entomol. 66:555-556.
- Proudfoot, F. G. 1973. Response of broilers to variations in waterer, feeder, and floor space under continuous and intermittent photoperiods. Can. J. Anim. Sci. 53:349-354.
- Proudfoot, F. G. 1973. Effects on broiler performance of a single generation of sire selection for body weight at eight weeks of age from two commercial parental genotypes reared on six dietary treatments. Can. J. Anim. Sci. 53:381-388.
- Proudfoot, F. G. 1973. Effects on small-end-up egg orientation on Haugh unit scores after storage for 8 and 15 days. Can. J. Anim. Sci. 53:415-416.
- Proudfoot, F. G. 1973. Effects of feeding grit on the performance of Leghorns housed in cages and fed on all-mash laying diet. Can. J. Anim. Sci. 53:601-603.
- Proudfoot, F. G., Gunn, J. D., and Allaby, S. F. 1973. Effects on broiler performance of using heated floors for rearing in a litterless environment. Can. J. Anim. Sci. 53:605-607.
- Proudfoot, F. G., and Lamoreux, W. F. 1973. The bio-economic effect of nutrient intake restrictions during the rearing period and post 'peak' egg production feed restriction on four commercial meat-type parental genotypes. Poult. Sci. 52:1269-1282.
- Ross, R. G. 1973. Suppression of perithecium formation in *Venturia inaequalis* by seasonal sprays of benomyl and thiophanate-methyl. Can. J. Plant Sci. 53:601-602.
- Ross, R. G., and Gourley, C. O. 1973. Crown rot of apple trees in Nova Scotia. Can. Plant Dis. Surv. 53:1-4.
- Thompson, L. S., Cutcliffe, J. A., Gourley, C. O., and Murray, R. A. 1973. Evaluation of several insecticides for control of strawberry green petal disease. Can. Plant Dis. Surv. 53:16-18.
- Townsend, L. R. 1973. Effects of N, P, K, and Mg on the growth and productivity of the highbush blueberry. Can. J. Plant Sci. 53:161-168.
- Townsend, L. R. 1973. Effects of soil amendments on the growth and productivity of the highbush blueberry. Can. J. Plant Sci. 53:571-577.
- Webster, D. H. 1973. Absorption of magnesium by McIntosh apple leaves as influenced by spray composition and weather conditions. Can. J. Plant Sci. 53:579-584.

Miscellaneous

- Cox, A. C. 1973. How can egg producers reduce feed costs? Canadex 451.50.
- Craig, D. L. 1973. Grape, home garden cultural guide. Agdex 231-12, pp. 1-4.
- Craig, D. L. 1973. Raspberry, home garden cultural guide. Agdex 237-12, pp. 1-4.
- Craig, D. L. 1973. Rhododendron and azalea winter hardiness evaluation. Rhododendron Soc. Can. Bull. 2(1):15-18.
- Craig, D. L. 1973. Strawberry cultivars at Kentville, N.S. Canadex 323.33.
- Crowe, A. D. 1973. Performance of some cultivar strains and apple rootstocks in Nova Scotia. Mass. Fruit Grow. Assoc. Annu. Proc. 79:90-96.
- Crowe, A. D. 1973. Comeback of an old-timer. Am. Fruit Grow. 93:16, 34.
- Crowe, A. D. 1973. Stocks for apples. Tree fruit protection guide for Atlantic Provinces. Atlantic Hort. Comm. (Agdex 211-24) 4 pp.

- Crowe, A. D., and Webster, D. H. 1973. Spur pruning of Red Delicious. Canadex 211.
- Herbert, H. S., and Butler, K. P. 1973. Effect of mite populations on leaf analysis. Canadex 211.
- MacLellan, C. R. 1973. Sex pheromones in codling moth control. N.S. Fruit Grow. Assoc. Annu. Rep. 109:43-50.
- Neilson, W. 1973. Sticky traps for apple maggot control. Canadex 211.
- Neilson, W. 1973. Effects of cold storage on maggot-infested fruit. Canadex 211.
- Neilson, W. T. A., and Sanford, K. H. 1972. Control of apple maggot in an integrated spray program. Proc. 19th Annu. Meet. Agric. Pestic. Soc., pp. 7-9.
- Proudfoot, F. G., Clevett, A. W., Cox, A. C., Lotherington, V. T. E., Smith, J. W., Bartlett, B. R., Black, E. O., Ramey, D. A., Aucoin, K. H., Allaby, S. F., McNeil, G. R., Ruet, J. L., Sefton, E. A., and Johnson, G. D. 1973. Broiler raising in Canada. Can. Dep. Agric. Publ. 1509. 48 pp.
- Research Station, Kentville, Nova Scotia. 1972. 1972 Annual Report. 93 pp.
- Ross, R. G. 1972. Spraying for apple scab. N.S. Fruit Grow. Assoc. Annu. Rep. 109:37-41.
- Wright, J. R. 1973. Report of Research Station, Kentville, Nova Scotia. pp. 19-28 in Research Branch report 1972. Agriculture Canada.

Research Station Fredericton, New Brunswick

PROFESSIONAL STAFF

G. M. WEAVER, B.Sc., Ph.D.	Director
F. J. WHITTEN	Administrative Officer
D. B. GAMMON, B.A., M.A., B.L.S.	Library Area Coordinator, Quebec and Atlantic Region

Environmental Quality Program

A. A. MACLEAN, B.Sc., M.Sc., Ph.D.	Program Manager; Soil chemistry
C. F. EVERETT, B.Sc., M.Sc., Ph.D.	Herbicides
W. A. HODGSON, B.Sc., M.Sc.	Fungicides
M. LANTAGNE, B.S.A., M.Sc.	Hydrological engineering
D. D. POND, B.Sc.	Insecticides

Livestock Feeding and Animal Nutrition Program

J. W. G. NICHOLSON, B.Sc., M.Sc., Ph.D.	Program Manager; Meat animal nutrition
P. L. BURGESS, B.Sc., M.Sc., Ph.D.	Dairy cattle nutrition
C. F. EVERETT, B.Sc., M.Sc., Ph.D.	Weed control
A. D. L. GORRILL, ¹ B.S.A., M.Sc., Ph.D.	Calf and lamb nutrition
E. A. GRANT B.Sc., M.Sc.	Forage and cereal crops
J. G. KEMP, B.E.	Harvesting and storage engineering

Potato Program

D. A. YOUNG, B.Sc., M.Sc., Ph.D.	Program Manager; Breeding
J. B. ADAMS (Mrs.), B.A., M.Sc.	Aphid physiology
R. H. BAGNALL, B.Sc., M.Sc., Ph.D.	Virus resistance
R. H. E. BRADLEY, B.Sc., Ph.D., D.Sc.	Aphid-borne viruses
M. C. CLARK, B.Sc., Ph.D.	Biochemistry of disease resistance
W. B. COLLINS, B.Sc., M.Sc., Ph.D.	Potato physiology
H. T. DAVIES, B.S.A.	Quality and breeding
H. DE JONG, B.A., M.Sc., Ph.D.	Diploid breeding and genetics
C. F. EVERETT, B.Sc., M.Sc., Ph.D.	Weed control
W. A. HODGSON, B.Sc., M.Sc., Ph.D.	Late blight

M. LANTAGNE, B.S.A., M.Sc.
 C. H. LAWRENCE, B.Sc., M.Sc.
 M. E. MACGILLIVRAY (Mrs.), B.A., M.Sc., D.Sc.
 A. R. MCKENZIE, B.Sc., M.Sc., Ph.D.
 G. C. MISENER,² B.Sc., M.Sc., Ph.D.
 D. D. POND, B.Sc.
 G. R. SAINI, B.Sc., M.Sc., Ph.D.
 R. P. SINGH,³ B.Sc., M.Sc., Ph.D.
 G. C. C. TAI, B.Sc., M.S., Ph.D.
 T. R. TARN, B.Sc., Ph.D.
 G. W. WOOD, B.Sc., M.A.

Soil erosion
 Soil-borne pathogens
 Insect ecology
 Soil-borne pathogens
 Harvesting and storage engineering
 Insect control
 Soil physics
 Virus diseases
 Quantitative genetics
 Cytogenetics
 Insect control, small fruits

Departures

C. R. LEE, B.Sc., M.Sc., Ph.D.
 Resigned September 1973
 J. P. MACKINNON, B.Sc., M.Sc.
 Transferred to Research Station, Charlottetown,
 P.E.I., July 1973

Potato nutrition
 Latent viruses

VISITING SCIENTIST

National Research Council postdoctorate fellow

H. R. SHARMA, B.Sc., Ph.D.

Ruminant nutrition

¹On transfer of work at University of Sydney, Sydney, Australia, July 1972 to July 1973.

²On educational leave, University of Illinois, Urbana, Ill., USA, until September 1973. Subsequently on transfer of work at Michigan State University, East Lansing, Mich., USA.

³On transfer of work at National Research Council, Ottawa, Ont., July 1973 to July 1974.

INTRODUCTION

The Research Station at Fredericton is the main location in Canada for research on the potato crop. Emphasis is placed on breeding and genetics, pest and disease management, harvesting and storage engineering, and soil and crop management. The Station is also the Atlantic center for harvesting and storage engineering, utilization and nutritional studies related to the production of cereal and forage crops for livestock feeding, and an environmental quality program relating to the impact of nutrients and pesticides on water quality. The Station collaborates with other Branch establishments in evaluating the potential of new crop cultivars and selected management practices in New Brunswick.

A major building addition to the laboratory complex was completed during the year. The new facilities have permitted the centralization of the executive, branch directorate, and headquarters staff of the New Brunswick Department of Agriculture and Rural Development. Personnel of the Production and Marketing Branch and the Health of Animals Branch of Agriculture Canada who were previously in various locations in the Fredericton area are now located at the Research Station. The physical integration of the federal and provincial departments has greatly facilitated communication and joint program development.

This report is a brief summary of the major thrusts undertaken during 1973. Additional information can be obtained from reprints of publications and through communication with the Station. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 280, Fredericton, N.B. E3B 4Z7.

G. M. Weaver
Director

LIVESTOCK FEEDS AND ANIMAL NUTRITION

Frost Heaving of Alfalfa

In the Atlantic region many seedings of alfalfa are lost because of frost heaving. These losses could be greatly reduced if farmers could be advised on the susceptibility of their soils to frost heaving, preferably by means of a simple laboratory determination. Soil samples were obtained from a number of fields that had been rated for susceptibility to frost heaving into three categories: low, medium, and high. When the samples were subjected to a series of laboratory determinations, moisture equivalent was found to correlate most closely with field ratings of susceptibility. Soils with a moisture equivalent below 24% have a low risk of heaving, those above 29% have a high risk, and soils between these percentages have a medium rating. These results suggest that the establishment of a routine diagnostic service would be helpful to producers.

Field Peas and Fababeans for Dairy Cattle

Concentrates containing soybean meal (15%), field peas (50%), field peas (22.5%) plus urea (1%), and fababeans (32%) as

protein sources were compared in a 4×4 Latin square design. The dry-matter intake was similar for the cows on each of the four concentrates, and the cows produced the same amount of milk. Also, differences in milk fat, solids-not-fat, and protein percentages were not significant ($P > 0.05$). No differences were observed in the acceptability of the four concentrates, and when the protein sources were adjusted for protein content, they were rated equal in feeding value for dairy cows.

Timothy Silage for Dairy Cattle

A forage system based on timothy silage offers a viable alternative to legumes and corn silage in most Maritime areas. Four timothy cultivars (Clair, Champ, Climax, and Bounty) having various maturity dates were seeded in pure stands and fertilized annually with 15-5-15 at 785 kg/ha in a split application. Each cultivar was harvested twice at the early head stage of plant maturity, wilted to 65% moisture before chopping, and stored in concrete silos. The system permitted a total harvesting period of 42 days in 1972 and 36 days in 1973. Dry-matter yields for the 2 yr averaged 8,400 kg/ha, which is 10% higher than the long-term yields of corn silage on

adjoining fields. The mean crude protein content of the crop in 1972 was 12.9%.

In two feeding trials with Holstein cows first- and second-cut timothy silage was compared with corn silage plus 0.5% urea. It was found that dry-matter intakes, body weight gains, and total milk yields were the same. Acetate levels in the rumen were higher for cows fed the timothy silages, although cows fed the corn silage produced milk with a higher fat content.

Results indicate that intensive management of timothy can provide a reliable source of high-quality forage for dairy cattle.

Field Drying of Timothy and Alfalfa Hay

Data gathered over 2 yr on the drying of timothy and alfalfa hay in the field were used to obtain multiple regression equations in which the dependent variable, percentage moisture content (on a dry weight basis) at the end of the day, was related to the percentage moisture content at the beginning of the day and the latent evaporation from an atmometer during the drying period. Linear and exponential equations gave good fits for both timothy and alfalfa data.

The Utilization of Urea in Beef Rations

A procedure developed at Iowa State University for estimating the amount of urea that can be used in rations for beef cattle was tested in two feeding trials with feeds typical of Eastern Canada. The performance of the animals was accurately predicted on the basis of the urea fermentation potential (UFP) of the ration.

In the first trial, beef calves were fed a ration of potatoes, corn silage, and supplement. The supplements varied in amount and source of crude protein. The average daily gains obtained with the different supplements varied from 0.50 to 0.76 kg. In the second trial, in which older beef cattle were fed corn silage ad lib. plus a supplement, the average daily gains were similar when the supplementary crude protein was supplied by urea or by rapeseed meal. The results show that older cattle fed ad lib. can utilize nonprotein nitrogen efficiently, but younger cattle on restricted energy intakes require preformed protein (such as rapeseed meal) for optimum performance.

Gains With Choline Chloride Not Confirmed

In experiments conducted this year, previous reports that the addition of choline chloride to the ration of beef calves increased average daily gains by 10% were not confirmed. Beef cattle averaging 370 kg were fed corn silage ad lib. plus 2 kg/day of a choline chloride supplement. The supplement may be beneficial when urea provides most of the supplementary protein but not when plant protein is supplied.

Formaldehyde-treated Rapeseed Meal

Much of the protein in diets fed to ruminant animals is degraded in the rumen. The nitrogenous compounds that are produced compete with the nitrogen from nonprotein sources for synthesis into microbial protein. Treating dietary protein with dilute formaldehyde has been shown to reduce its degradation in the rumen without significantly reducing digestion in the lower tract. Beef heifers were fed daily 3.6 kg of corn silage, 0.32 kg of rapeseed meal, and ad lib. cane molasses with 2% added urea. When the rapeseed meal was treated with formaldehyde, the average daily gain increased by 30%. When a higher level (0.6 kg) of rapeseed meal was fed, the formaldehyde treatment had no effect on animal performance.

Urea Addition to Cereal Silage

Urea is often added to corn as it is being ensiled to increase the crude protein value of the resulting silage. Silage made from the whole plant of cereals is low in crude protein, but it becomes a better balanced feed when urea is added. Two feeding trials, one with barley and the other with oats, showed that the addition of 4 kg of urea/t of fresh cereals fed to cattle did not reduce silage consumption. The added urea was used as efficiently with cereals as when it was added to the grain supplement at time of feeding.

Potatoes—A Safe Feed

Potato sprouts and sunburned potatoes are known to contain compounds called glycoalkaloids, which are toxic to simple-stomached animals. It is not known how much of these compounds are needed to produce clinical symptoms in ruminant animals or if consuming high levels of sunburned cull potatoes or peel waste from a processing plant might be toxic. Glycoalkaloids were extracted from

green-sprouted potatoes and fed to sheep in graded doses. Levels below 5 g did not produce any symptoms. In most instances this level would be equivalent to more than 25 kg of potatoes. In vitro studies with rumen fluid showed that the bacteria could break down the glycoalkaloids. Also, the addition of glycoalkaloids did not reduce the number of viable bacteria or their ability to digest cellulose in vitro. Ruminant animals apparently are more resistant to glycoalkaloid poisoning than simple-stomached animals.

Nutritive Value of Rapeseed Protein and Oil

Experiments carried out at the University of Sydney, Sydney, Australia, showed that a dehulled, heated, and water-extracted protein concentrate from Bronowski rapeseed (RPC), prepared by the Food Research Institute, Ottawa, was a good protein source for weanling rats and milk-fed lambs. Growth, feed intake, and protein efficiency ratios of rats fed diets containing RPC were superior to those fed diets containing casein or dehulled raw rapeseed flour. Rats fed the raw rapeseed flour diet developed enlarged livers; but when the flour was heated, growth of the rats increased and the size of the livers was reduced. The addition of limiting amino acids to the rapeseed protein had no significant effect on rat performance. Apparent nitrogen digestion by lambs was relatively low with high erucic acid rapeseed oils in the milk replacer. In lambs, high erucic acid rapeseed oils also caused fat infiltration of liver tissue and enlarged thyroid.

Full-fat Soybean Flour in Milk Replacers for Lambs

A full-fat soybean flour (FFSF), prepared by the Food Research Institute, Ottawa, has been used in experiments on milk replacers for lambs here and at La Pocatière and Lennoxville, Que. When the FFSF supplied half of the protein in the milk replacer, digestion coefficients for dry matter, nitrogen, and energy were only about 3% lower than for an all-milk protein formula. Growth of lambs was similar when they were fed for 3–4 wk on milk replacers containing only milk protein or on milk replacers having half the protein supplied by FFSF. Also there was no effect on dressing percent, finish, and color scores of carcasses from lambs killed at 18 or 40 kg liveweight. Evaluations by a taste

panel are being completed at the Food Research Institute, Ottawa.

Protein Levels in Creep Feeds for Lambs

Creep feeds containing 15, 20, and 25% crude protein were fed to lambs at the Experimental Farm, Nappan, N.S. The lambs also received cold milk replacer ad lib. to 24 days of age. Growth data to 70 days of age indicated that a creep feed containing 20% crude protein was adequate for early weaned lambs.

POTATO BREEDING

New Table Stock Cultivar

A promising new seedling, F58010, will be named and submitted for licensing in 1974. This cultivar is a very high quality table stock for the main crop, maturing about the same time as Green Mountain and Katahdin. It has exceptional handling qualities, and its yield compares favorably with that of the high-performance standard, Kennebec. This seedling also exhibits a moderate level of resistance to common scab, late blight tuber rot, and *Fusarium sambucinum* Fckl. f. 6 Wr.

Promising New Early Chipping Seedling

Seedling F61025 is in the final stages of evaluation and probably will be released in 1975. It is an early maturing selection that is equal to Warba in marketable yield when dug at 80 days and to Kennebec when dug as a main crop. It chips well when it is harvested early, stored at 55°F, and reconditioned from 44°F. Also, it has scored well in boiling and baking trials. The tubers are uniform in shape and are white with pale pink eyes. The seedling is moderately resistant to *Verticillium albo-atrum* Reinke & Berth., *F. sambucinum* Fckl. f. 6 Wr., *F. coeruleum* (Lib.) Sacc., and leaf roll, and highly resistant to virus Y.

Diploid Breeding

A diploid breeding program has been initiated whereby haploids are extracted from tetraploid cultivars and superior breeding stocks. Superior haploids and haploid-haploid hybrids are used in crosses with wild and cultivated diploid species. Advanced hybrids offer a good deal of potential for selection and genetic studies of several traits of economic importance. Superior diploid

breeding stocks, which produce a relatively high frequency of unreduced gametes, can be used in further hybridizations to return to the tetraploid level via the $4\times-2\times$ method of recombination.

Consistent High Yields from Potato Hybrids

Andigena (A) and Tuberosum (T) clones were intercrossed to establish four populations representing the two parental (AA and TT) and the two F_1 (AT and TA) combinations. The first clonal generation was grown in the field in 1972, when the AA, AT, and TA populations all significantly outyielded the TT population. In 1973, the mean yield per hill of the TT population more than doubled, the yields of the two hybrid populations increased about 75%, and the yield of the AA population increased by only 45%. These results changed the ranking so that TT (1,335 g per hill) was third behind the hybrid populations (1,512 g per hill for TA and 1,434 g for AT) and the AA population had the lowest yield (1,189 g per hill).

Even with these changes in yield from 1972 the hybrid populations showed marked heterosis (14.1% for TA and 7.9% for AT) over the high parent (TT). These values were about half those for 1972. Heterosis over the mid-parent value was 20.2% for TA and 13.7% for AT, about the same values as for 1972.

In contrast with the higher total yields per hill, two yield components (tuber number and mean tuber weight) ranked in the same order for both years. The TT population had the lowest tuber numbers and the highest mean tuber weight, and the AA population had the highest tuber numbers and the lowest mean tuber weight. Because these yield components showed a similar relative performance for the four populations in 2 yr, the changes in yield ranking must result from the multiplicative effect of the yield components. The greater stability in the performance of these hybrids is the chief advantage of such hybrid material.

In plant vigor the hybrids resembled the AA population, but in maturity they were related more closely to TT populations. In addition, the hybrids tended to have heavy root systems, undesirable stolon types, deep eyes, roughness, and poor appearance, and in these respects they were closer to AA than to TT.

Resistance to Potato Virus S

Although the cultivar Saco is highly resistant to potato virus S (PVS), it has a very rough tuber, a characteristic that is transmitted to many of its seedling progeny. Consequently, a search was undertaken to determine whether PVS resistance could be found in potatoes not related to Saco. A number of seedlings that are being used in our breeding program were crossed with Saco, and samples of the resulting progeny were tested for PVS resistance. The resistance is inherited as a simple recessive, and the genotype of Saco is *ssss*. A cross between Saco and a parent with a genotype of *SSSS* or *SSSs* would produce no resistant seedlings; genotype *SSss*, 16%; genotype *Ssss*, 50%; and genotype *ssss*, 100%. No seedling unrelated to Saco has been found to have the genotype *ssss*. However, one appears to be *Ssss* and several *SSss*.

Aphid Resistance in *Solanum*

Field studies established the reliability of a nondestructive electronic laboratory technique to select *Solanum* plants resistant to three species of potato-infesting aphids, *Myzus persicae* (Sulzer), *Macrosiphum euphorbiae* (Thomas), and *Aphis nasturtii* Kalténbach.

Thirty-nine named and unnamed cultivars of *Solanum tuberosum* L. from our potato-breeding program were challenged in the field and laboratory for their aphid response. One seedling, F53013, was very much more resistant to the three species of aphid than the control, Katahdin. This seedling had been kept in the program because of its resistance to *Phoma*, *Verticillium*, and *Fusarium* spp.

Twelve species of *Solanum*, *S. andigenum*, *S. chacoense*, *S. bulbocastanum*, *S. phureja*, *S. polyadenium*, *S. polytrichon*, *S. canasense*, *S. multidissectum*, *S. aplocense*, *S. stoloniferum*, *S. brachistotrichum*, and *S. sanctae-rosae*, were examined in the field and the laboratory for aphid resistance. All the *S. andigenum* examined were susceptible to feeding and damage by aphids; various degrees of resistance were found in the other species, with the highest incidence of resistance in *S. sanctae-rosae*. Crosses have been made between resistant selections.

Testing Potato Cultivars for Aphid Resistance Under Field Conditions

Sixteen potato cultivars and parental lines were tested in 1972 and 1973 for their resistance to three common species of aphid, *M. euphorbiae*, *M. persicae*, and *A. nasturtii*, under natural conditions in the field. The aphids were counted on different parts of the plant (top, middle, and bottom) in July and August. Significant differences were detected for *A. nasturtii* in total counts and in counts on the middle part of the plant after August 15. The rank correlation coefficient ($r = 0.6$) for total counts for both years indicated that varietal differences for resistance to *A. nasturtii* can be detected in the field in late August. No significant difference was detected for the other two species of aphid.

POTATO PATHOLOGY

Interplot Interference in Late Blight Control

Studies were carried out in cooperation with the research stations at Ottawa and Charlottetown to determine interplot interference that occurs in field experiments involving potatoes infected with late blight. It is apparent that the presence of an induced epidemic in an experiment interferes with evaluation of adjacent unsprayed plots. This same effect should be considered in evaluation studies on fungicides and in determining the resistance of seedlings when both highly susceptible and resistant seedlings are present.

Survey of Races of Late Blight Prevalent in Eastern Canada

A survey of the races of late blight of potato that are prevalent in Eastern Canada was completed. Three races of the fungus were found: race 1.4 was present in 60% of the samples examined; race 4 in 35%, and race 1 in 5%. The predominant race in New Brunswick and Quebec was 1.4 but in Prince Edward Island, where fewer cultivars that carry the gene R_1 are grown, races 4 and 1.4 occurred in about equal numbers in the 32 samples examined.

A Potential Cultural Control for Verticillium Wilt of Potatoes

Two growers whose crops of Kennebec seed potatoes were rejected because of wilt

cooperated in testing the effects of removing the postharvest potato residues from parts of their wilt-infested fields. Both growers removed the potato residues and planted Kennebec seed that was free from wilt. Reductions of 30–40% in the incidence of wilt were recorded in areas where most of the residues had been removed instead of being incorporated into the soil, the usual practice. These trials will be continued and expanded to determine the effectiveness of this procedure for eliminating wilt or reducing it to acceptable levels, how often it must be done to achieve and maintain these levels, and the effect that removing the residues has on the physical properties of the soil.

POTATO ENTOMOLOGY

Pest Management

The initial phase of a potato-pest management program was begun in 1973 in cooperation with the departments of agriculture for Maine and New Brunswick. Schools were conducted in Maine and New Brunswick, where elite growers and extension and research personnel were taught how to identify potato-infesting aphids as a background for field and trap monitoring. Twelve monitoring stations were established in New Brunswick, where the numbers of each species of aphids on 10 haulms in each plot were counted weekly from July 10 until the tops were killed. The numbers of *M. persicae*, the green peach aphid, were estimated by counting the aphids caught in yellow water traps. The plots and traps complemented similar ones located in Maine. Temperature and relative humidity were recorded for use in interpreting trends in the behavior of insect populations. The results from plot and trap counts of aphids showed that numbers and species vary with location, field, and variety of potato. *M. persicae* was not the most common aphid in all the plots, but each trap caught at least one specimen. From the information recorded each week in the plots and traps, it was possible to recommend with greater precision the timing for application of insecticides and crop desiccants to protect the potatoes from direct and indirect insect damage.

Evaluation of Spray Systems for Insect and Disease Control in Row Crops

Endosulfan 4E at 0.56 kg/ha active was used to test two types of booms at various pressures for the control of potato insects.

A straight boom with three nozzles per row was more effective for controlling the Colorado potato beetle at 30 or 50 psi than a boom with one overhead and two drop nozzles per row. The reverse was true at 250 and 400 psi.

Drop nozzles were more effective at all pressures for the control of the buckthorn aphid, but the straight boom was more efficient for the control of the green peach aphid.

Poor control of blight was obtained with mancozeb 80% wettable powder (wp) at 1.3 kg/ha active at 30 psi with both booms and also with the straight boom at 50 psi. Good control of blight was achieved with drop nozzles at 50 psi and with either boom at 250 or 400 psi.

Control of the Colorado Potato Beetle

Endosulfan 4E at 0.56 kg/ha active gave 100% control of first- and second-instar larvae but only 74–95% control of the third-instar larvae. Carbaryl 85% wp at 1.1 kg/ha active gave good control of first-, second-, and early third-instar larvae. Disulfoton 15% granular banded at 3.4 kg/ha active or carbofuran 10% granular banded at 1.1 kg/ha active gave good control of the Colorado potato beetle.

Control of the Potato Flea Beetle

Carbofuran 10% granular at 1.1 kg/ha active, disulfoton 15% granular at 3.4 kg/ha active, AC92100 (Cyanamid of Canada Ltd.) 15% granular at 3.4 kg/ha active, and Bayer 92114 (Chemagro) 10% granular at 2.2 kg/ha active banded at planting gave 99%, 95%, 94%, and 52% control of the potato flea beetle. Carbaryl 85% wp at 1.1 kg/ha active was little better than the untreated control.

Control of Potato Aphids

Disulfoton 15% granular banded at 3.4 kg/ha active at planting gave good control of the potato, the buckthorn, and the green peach aphid for the season.

Carbofuran 10% granular banded at 1.1 kg/ha active gave good control of the potato and the buckthorn aphid but not the green peach aphid.

Populations of the green peach aphid were greater on plots sprayed with fenitrothion 10EC at 1.1 kg/ha active or Bay Hox 1901 4E (Chemagro) at 0.56 kg/ha active plus azinphos-methyl 2.4E at 0.3 kg/ha active than on the untreated plots. With dimethoate 4E at 1.1 kg/ha active and PP062 50% wp at 0.28 kg/ha active, the green peach aphid populations were approximately the same as on the untreated check plots.

Control of Wireworms

Carbofuran 10% granular at 1.1 kg/ha active and disulfoton 15% granular at 3.4 kg/ha banded at planting were the only treatments that significantly reduced damage by wireworms.

POTATO PHYSIOLOGY, CROP AND SOIL MANAGEMENT

Growth Analysis

A comparison of the growth and production of three seedlings having distinctly different growth characteristics was conducted with the use of growth analysis techniques in order to obtain preliminary information on factors that may be limiting to growth and yield in the potato.

Two of the seedlings characterized by relatively small canopy (average leaf-area indexes of 3.1 and 3.6) were found to produce more dry matter per unit of leaf area than the third seedling, which had a larger canopy (an average leaf-area index of 4.8). Seedlings with smaller canopies may be more efficient because of better light distribution; alternatively, since tuber yields were practically identical among the seedlings, the lower efficiency value for the large seedling may merely indicate a similar sink demand spread over the greater available leaf surface.

Effects of Mechanically Induced Compaction

In a greenhouse experiment, compaction did not significantly affect the phosphorus 'A value' of Holmesville and Caribou soils. The addition of shredded tree bark (30 t/ha, dry basis) increased the 'A value' of both soils.

In a laboratory experiment, the effect of compaction on the transformation of NH_4^+ to NO_3^- was also studied in Holmesville and

Caribou soils. Indications are that compaction may reduce the rate of transformation of NH_4^+ to NO_3^- .

Soil Erosion

Two plots were established in 1973 in the potato-growing region of the Upper Saint John River Valley to study methods of controlling soil erosion. One plot (1 ha) consists of a sloping field having the rows of potatoes running with the slope. The other plot (2.4 ha) consists of a parallel diversion terrace system, in which the rows of potatoes are running across the slope.

The objectives of these studies are to evaluate the effectiveness of parallel diversion terrace systems for controlling soil erosion and restricting runoff of nutrients and pesticides in a potato production system, and the effect of terracing on the water balance, soil moisture content, and potato yield.

No significant differences were found in the total yield of potato. However, the yield of marketable potatoes was 27% higher on the terraced plot.

FRUIT CROPS

Prototype Apple Harvesting

An improved limb shaker mounted on the rear of a Massey Ferguson 135 tractor and powered by a hydraulic pump driven by the tractor power take-off was tested. The retractable boom with 180° horizontal and 90° vertical swing and 180° rotation easily and quickly positioned the clamp for attachment to limbs. When the machine was shaking for juice apples, 30–40 trees/hr were harvested. This machinery was also used with a flat-bed collector for harvesting processing apples. A simple and effective bin filler has been designed for the flat-bed collector.

Promising Chemical Control for Blueberry Maggot and Birds

Preliminary trials with an experimental insecticide, methiocarb (Mesurol; Chemagro), showed it to be promising for control of the blueberry maggot, *Rhagoletis mendax* Curran. As a result of one application of this

material sprayed on July 23, when approximately 25% of the berries had turned blue, berries examined in mid-August showed a reduction of 96% in maggot content in comparison with counts in an unsprayed field. In another test, one application of methiocarb reduced the losses of ripe fruit to birds by half. The results of these tests suggest that methiocarb may be useful in controlling the two major pests in blueberry production.

ENVIRONMENTAL QUALITY

Nutrient Discharge from Agricultural Watersheds

A program was started in 1971 in the potato-producing region of the Saint John River Valley to investigate the effects of agricultural practices on water quality. An integral component of this program has related to nutrient concentrations of water and nutrient discharge by streams.

Nutrient concentration and water discharge were assessed in two watersheds, Holmesville (3,700 ha) and St. André (1,630 ha), to provide data for three intensities of agriculture: background level from nonagricultural forested area; medium intensity agriculture, 40% in crop production; and intensive agriculture, 72% in crop production.

Mean concentrations from weekly sampling data (1971–73) for the sites representing background level and intensive agriculture were $\text{NO}_3\text{-N}$, 0.6 vs. 3.2 ppm; inorganic P, 3 vs. 9 ppb; K, 0.4 vs. 1.2 ppm; Ca, 16 vs. 60 ppm; Mg, 2.2 vs. 4.8 ppm; Cl, 1.1 vs. 10.9 ppm; and SO_4 , 6 vs. 23 ppm. Also, annual discharges of these nutrients per unit area were calculated from concentration, water discharge, and watershed area data. Annual discharges per hectare for the nonagricultural and intensive agricultural areas were $\text{NO}_3\text{-N}$, 2 vs. 3 kg; P, 25 vs. 60 g; K, 3 vs. 8 kg; Ca, 104 vs. 311 kg; Mg, 14 vs. 23 kg; Cl, 8 vs. 59 kg; and SO_4 , 42 vs. 113 kg.

Concentration and discharge of nutrients from the area representing a medium intensity of agriculture were in an intermediate range.

Associated studies started in 1973 relate to the nutrient contents of well water and of tile drainage effluent.

PUBLICATIONS

Research

- Burgess, P. L., Nicholson, J. W. G., and Grant, E. A. 1973. Yield and nutritive value of corn, barley, wheat and forage oats as silage for lactating dairy cows. *Can. J. Anim. Sci.* 53:245-250.
- Childers, W. R., and Grant, E. A. 1973. Bounty timothy. *Can. J. Plant Sci.* 53:131-133.
- Chiykowski, L. N., Colpitts, S. R., Coulombe, L. J., Delbridge, R. W., Gourley, C. O., Lawrence, C. H., Murray, R. A., Santerre, J., and Thompson, L. S. 1973. Strawberry green petal disease in Quebec and the Maritime Provinces, 1971-72. *Can. Plant Dis. Surv.* 53:63-66.
- Grant, E. A., and Saini, G. R. 1973. Testing soils to predict their susceptibility to frost heaving of alfalfa (*Medicago sativa*). *Can. J. Plant Sci.* 53:821-822.
- Harris, K. F., and Bradley, R. H. E. 1973. Importance of leaf hairs in the transmission of tobacco mosaic virus by aphids. *Virology* 52:295-300.
- James, W. C., Lawrence, C. H., and Shih, C. S. 1973. Yield losses due to missing plants in potato crops. *Am. Potato J.* 50:345-352.
- James, W. C., Shih, C. S., Callbeck, L. C., and Hodgson, W. A. 1973. Interplot interference in field experiments with late blight of potato (*Phytophthora infestans*). *Phytopathology* 63:1269-1275.
- James, W. C., Shih, C. S., Hodgson, W. A., and Callbeck, L. C. 1973. A method for estimating the decrease in marketable tubers caused by potato late blight. *Am. Potato J.* 50:19-23.
- Misener, G. C., and Lee, J. H. A. 1973. Aerodynamic separation of grain from straw and chaff in a dispersed stream. *Can. Agric. Eng. J.* 15(2):62-65.
- Saini, G. R. 1973. Relationship between soil oxygen diffusion rate and yield of oats in a coastal alluvial soil at critical salinity level. *Agron. J.* 65:841-842.
- Singh, R. P. 1973. Experimental host range of the potato spindle tuber 'virus'. *Am. Potato J.* 50:111-123.
- Wang, C., and Arnold, R. W. 1973. Quantifying pedogenesis for soils with discontinuities. *Soil Sci. Soc. Am. Proc.* 37:271-278.
- Wang, C., and Wood, F. A. 1973. A modified aluminon reagent for the determination of aluminum in soil extracts after acid digestion. *Can. J. Soil Sci.* 53:237-239.

Miscellaneous

- Bagnall, R. H., Singh, R. P., and Clark, M. C. 1973. The strange case of potato spindle tuber. *Can. Agric.* 18(2):3-5.
- Gorrill, A. D. L. 1973. Protein for calf starters and growers. *Canadex* 410.64.
- Gorrill, A. D. L., Brisson, G. J., Emmons, D. B., and St. Laurent, G. J. 1973. Artificial rearing of young lambs. *Can. Dep. Agric. Publ.* 1507. 21 pp.
- Grant, E. A., and Saini, G. R. 1973. Susceptibility of soils to frost heaving of alfalfa. *Canadex* 510.
- Hodgson, W. A., Munro, J., and Pond, D. D. 1973. Diseases and pests of potatoes. *Can. Dep. Agric. Publ.* 1492.
- Kemp, J. G. 1973. Grain losses due to delayed harvesting. *Canadex* 110.50.
- Lee, C. R. 1973. Soil acidity and potato production. *Can. Agric.* 18(1):12-14.
- Nicholson, J. W. G. 1973. Should beef heifers produce a calf before going to market? *Canadex* 420.10.
- Nicholson, J. W. G. 1973. Dust bags help control flies on cattle. *Canadex* 401.651.
- Roberts, J. A., Linkletter, A., Misener, G., and Allen, D. 1973. Bulk potato storage. *Can. Dep. Agric. Publ.* 1508.

Ferme expérimentale L'Assomption, Québec

CADRES PROFESSIONNELS

P. P. LUKOSEVICIUS, Diplomlandwirt, M.Sc., Ph.D. Directeur

Tabac

M. DUPRÉ, B.A., B.S.A.

V. KOZUMPLIK, Diplomirani inženjer poljoprivrede,
M.Sc.

M. LAMARRE, B.Sc. (Agr.)

Pesticides

Génétique et amélioration
du tabac à cigare

Phytotechnie

INTRODUCTION

Le programme de recherches de cette Ferme est axé principalement sur les travaux concernant les tabacs à cigare et à cigarette. Il englobe aussi la production du tabac à pipe.

Ce rapport présente un bref résumé des recherches poursuivies en 1973. Les chercheurs collaborent avec d'autres agronomes du Québec afin de faire des recommandations sur la production des tabacs. Une coopération étroite existe aussi avec les représentants des associations de producteurs et avec les fabricants du tabac à cigare et à cigarette.

Les résultats consignés dans ce rapport ne représentent qu'une partie de la recherche en cours. Pour obtenir de plus amples renseignements, adresser les demandes à la Ferme expérimentale, Agriculture Canada, C.P. 1070, L'Assomption, Qué. J0K 1G0.

P. P. Lukosevicius
Directeur

TABAC

Tabac à cigare

Évaluation du «plasma germinatif». En 1973, à l'Assomption, nous avons cultivé 24 cultivars de tabac à cigare et à pipe, d'origine canadienne et extérieure, afin d'en déterminer les caractéristiques morphologiques et autres. Le but principal de cette expérience était pourtant de définir les cultivars possédant les caractéristiques propres à la récolte mécanique.

L'analyse des caractéristiques morphologiques, agronomiques et chimiques a démontré des écarts considérables entre les cultivars. Nous avons observé des variations du pourcentage des feuilles endommagées par le chauffage à la pente, ainsi que de la résistance des plants à la pourriture noire des racines. Aucun des cultivars ne s'est classé au premier rang plus de trois fois dans les 24 caractéristiques analysées. Quelques cultivars seulement ne se sont pas classés acceptables pour au moins une des caractéristiques étudiées.

Il résulte de cette expérience que, dans le programme d'amélioration du tabac à cigare, l'emploi de plants synthétiques au lieu de croisements simples, doubles ou de triples géniteurs donnerait des résultats plus satisfaisants.

Dates de plantation et distance entre les plants du tabac à cigare. En 1973, comme par les années précédentes, le cultivar commercial Ottawa 705 et la lignée hybride L64-169 ont été plantés à différentes dates: le 26 mai, le 9 juin ou le 23 juin; les plants étaient espacés de 36, 41 ou 46 cm (14, 16 ou 18 po) sur des rangs distancés de 97 cm (38 po).

En moyenne, les plants mis en terre plus hâtivement et distancés de 41 cm (16 po) ont donné les meilleurs résultats.

Considérant, en plus, les avantages d'une température plus favorable au séchage lorsque la récolte se fait plus à bonne heure, il est à recommander de planter le tabac avant le 9 juin. Quant aux distances, elles devraient être de 41 cm (16 po) entre les plants et de 97 cm (38 po) entre les rangs.

Séchage. Les études sur le séchage du tabac à cigare se sont poursuivies en 1973. On a fait sécher le cultivar commercial Ottawa 705 dans des séchoirs et des chambres de séchage à traitements variés. Dans les séchoirs, on a fourni un chauffage au charbon de bois et une ventilation électrique comme aides supplémentaires aux conditions naturelles. Dans les chambres de séchage, le tabac a été soumis à des combinaisons variées de température et d'humidité relative.

Les résultats obtenus de ces traitements en 1973 et durant les années précédentes démontrent qu'une chaleur et une ventilation supplémentaires améliorent la qualité du tabac à cigare lorsque les conditions naturelles ne sont pas favorables au séchage. Par contre, le mauvais usage de ces aides supplémentaires peut donner des effets négatifs sur la qualité du tabac à cigare.

L'effet de l'âge du fumeur sur sa préférence pour les cigares d'un cultivar de tabac. Nous avons envoyé des cigares confectionnés avec neuf cultivars de tabac à cigare, provenant d'un test fait en 1968, à un jury de dégustation afin de déterminer l'acceptabilité des cultivars. Le jury était composé de 256 membres situés dans toutes les régions du Canada et dont l'âge variait de 21 à 71 ans.

L'étude a considéré l'âge de chaque fumeur en relation avec sa préférence pour un cultivar donné.

La préférence des fumeurs pour les cigares confectionnés avec le cultivar témoin Ottawa 705 diminuait avec l'augmentation de l'âge. Le coefficient de corrélation négatif était significatif à un niveau de 5%.

Répression des mauvaises herbes. Tous les traitements herbicides ont permis un rendement supérieur à celui du témoin soumis à deux sarclages mécaniques. Le benfluralin au taux de 7,26 kg/ha (6 lb/ac) combiné à deux sarclages a donné le rendement le plus élevé, 1 852 kg/ha (1 652 lb/ac), soit 443 kg/ha (395 lb/ac) de plus que celui du témoin. Le diphénamid au taux de 9 kg/ha (7,5 lb/ac) avec un seul sarclage a rendu 1 803 kg/ha (1 608 lb/ac), alors que le deuxième sarclage a entraîné une diminution de 282 kg/ha (252 lb/ac). Le rendement moyen de tous les traitements herbicides combinés à un seul sarclage a dépassé de 471 kg/ha (420 lb/ac) celui du témoin de la même classe. Lorsque les traitements herbicides se sont combinés à deux sarclages, le rendement moyen a été supérieur de 212 kg/ha (189 lb/ac) à celui du témoin soumis à deux sarclages, et de 498 kg/ha (444 lb/ac) à celui du témoin soumis à un seul sarclage. Le benfluralin au taux de 7,26 kg/ha (6 lb/ac) avec deux sarclages a procuré le plus haut revenu, \$1 046/ha (\$423/ac). Le revenu moyen des traitements herbicides avec un sarclage a été de \$330/ha (\$134/ac) supérieur à celui du témoin de la même classe.

Tabac à cigarette

Évaluation des cultivars. En 1973, nous avons comparé entre eux 14 cultivars quant à leur valeur agronomique. Dix cultivars se sont révélés meilleurs que le témoin Hicks Broadleaf au point de vue rendement. Virginia 115 venait au premier rang. Deux cultivars seulement étaient inférieurs au témoin en terme de l'indice de qualité, Coker 347 se classant le meilleur. En ce qui concerne le revenu brut à l'acre, tous les cultivars surpassaient le témoin à l'exception d'un seul, inférieur; Speight G-41 s'avérait le meilleur. Quatre cultivars au plus furent supérieurs au témoin quant à l'indice de maturité.

L'effet de N, P et K sur le tabac. Ce projet s'est initié en 1973. Il comporte l'essai de quatre niveaux d'azote, quatre niveaux de

phosphore et quatre niveaux de potassium. De plus, chaque essai est effectué sur des types de sol différents, soit un sable, soit un limon sableux. Les résultats démontrent que, sur le sable, le rendement s'accroît avec une augmentation de la quantité d'azote appliquée. Il atteint son maximum avec une dose de 27 kg/ha (24 lb/ac). Sur le limon sableux, une application de 20 kg/ha (18 lb/ac) est suffisante pour obtenir le maximum de rendement. Une application de phosphore de 112 kg/ha (100 lb/ac) diminue le rendement et une application de 168 kg/ha (150 lb/ac) l'augmente, peu importe le type de sol. L'application de potassium favorise l'augmentation du rendement aussi bien sur le sable que sur le limon sableux.

Répression des drageons du tabac. En 1973, nous avons essayé six produits différents pour la répression des drageons; l'expérience comprenait aussi deux stades et deux méthodes d'application. Tous les produits ont assuré une répression supérieure à 75%, ce qui est très satisfaisant. Une application manuelle a été supérieure, au point de vue rendement et revenu, à une application à la machine. Si l'on compare les temps d'application, on se rend compte que le traitement avant écimage assure une meilleure répression, mais qu'il entraîne des taux moins élevés de rendement, de qualité, de revenu et de maturité.

Répression des mauvaises herbes. Tous les traitements herbicides ont augmenté le rendement et le revenu brut au-dessus de ceux des parcelles sarclées uniquement à la machine. Un deuxième sarclage des parcelles, à l'exception de celle traitée au benfluralin, a accru le rendement, soit de 2% avec le diphénamid (qu'il soit appliqué avant ou après la plantation), de 5% avec le témoin, de 6% avec le Devrinol (Stauffer Chemical Co.) et de 8% avec le pébulate. Lorsque les traitements herbicides étaient combinés à un seul sarclage mécanique, ceux au diphénamid appliqué avant la plantation, au Devrinol et au benfluralin ont augmenté les rendements de 437 kg/ha (390 lb/ac) au-dessus du rendement du témoin. Lorsque les parcelles aux traitements herbicides et le témoin étaient soumis à deux sarclages mécaniques, le rendement comparé au témoin s'est accru de 484 kg/ha (432 lb/ac) avec le Devrinol, de 407 kg/ha (363 lb/ac) avec le diphénamid avant la plantation, de 266 kg/ha (237 lb/ac) avec le pébulate, de 256 kg/ha

(228 lb/ac) avec le benfluralin et de 210 kg/ha (187 lb/ac) avec le diphénamid après la plantation.

Puisque les herbicides n'ont pas nui à la qualité du tabac, nous avons obtenu une augmentation du revenu brut de \$668/ha (\$270/ac).

Répression des vers gris. Des 197 postes d'observation installés chez 20 producteurs, 42 ont révélé des populations d'entre 1,2 et 2,2 millions de larves à l'hectare (entre 500 000 et 900 000 larves/ac), et 7 postes ont donné entre 2,5 et 3,5 millions/ha (entre 1,0 et 1,4 million/ac).

La cueillette des larves a laissé voir trois maximums, soit les 4, 11 et 20 juin, dates où nous avons récolté le plus de larves par cercle de 1,5 m (5 pi) de diamètre.

La prise de noctuelles à l'aide de pièges lumineux a révélé la présence de 26 espèces de ver gris. Onze espèces composaient chacune 1% et plus du total des vers gris et comprenaient 95% des vers gris adultes attrapés. Parmi les espèces dominantes figuraient *Amathes c-nigrum* L., *Crymodes devastator* (Brace), *Euxoa detersa* (Wlk.), *E. scandens* (Riley), *Nephelodes emmedonia* (Cram.), *Feltia ducens* (Wlk.) et *Agrotis ipsilon* (Hufn.).

Chez un producteur aux prises avec *E. scandens* et *E. detersa*, des traitements fractionnés au chlorpyrifos et au leptophos réduisent les dommages à 4, 6 ou 8% selon que les insecticides sont pulvérisés soit sur des planches en tabac et en seigle de rotation, soit sur des planches en tabac et en bordure de 6,1 m (20 pi) sur des planches en seigle, ou seulement sur des planches en seigle.

PUBLICATIONS

Divers

Lukosevicius, P. P. 1973, Production de tabac au Québec. Le Briquet 43(1):5-9.

Station de recherches Lennoxville, Québec

CADRES PROFESSIONNELS

Administration

C. S. BERNARD, B.S.A., M.Sc., Ph.D.	Directeur
L. M. SÉVIGNY (Mlle)	Agent, service administratif

Zootechnie

J. DUFOUR, B.S.A., M.Sc., Ph.D.	Chef de la section; physiologie
R. BOUCHARD, B.A., B.S.A., M.S.A., Ph.D.	Nutrition
M. H. FAHMY, B.Sc., M.Sc., Ph.D.	Génétique
P. FLIPOT, B.S.A., M.Sc.	Nutrition
L. LAFLAMME, B.S.A., M.Sc., Ph.D.	Nutrition
G. LALANDE, B.A., B.S.A.	Régie
G. ROY, B.S.A., M.Sc., Ph.D.	Génétique

Productions végétales

J.-L. DIONNE, B.A., B.S.A., Ph.D.	Chef de la section; fertilité des sols
J. GENEST, B.S.A., M.Sc.	Plantes fourragères
W. MASON, B.S.A., M.Sc.	Plantes fourragères
G. PELLETIER, B.S.A., M.Sc.	Utilisation des fourrages
A. PESANT, B.S.A., M.Sc.	Physique des sols

INTRODUCTION

Le but principal de cette Station est la recherche en production animale pour le Québec. Les études portent sur le bovin laitier, le bovin de boucherie, le mouton (en collaboration avec la ferme expérimentale de La Pocatière), et le porc (de concert avec la Station de recherches de l'Université Laval à St-Augustin). Ces études sont complétées par des recherches en production végétale qui visent à une meilleure utilisation des sols généralement acides et légèrement accidentés de l'est du Québec, ainsi qu'une production accrue des récoltes destinées à l'alimentation animale.

Ce rapport est un exposé succinct des quelques expériences poursuivies en 1973. Les résultats cités sont suffisamment fermes pour en tirer des conclusions. De plus amples détails se rapportant à toute la recherche en cours sont disponibles en adressant la demande à la Station de recherches, Agriculture Canada, Lennoxville, Qué. J0B 1Z0.

C. S. Bernard
Directeur

ZOOTECHNIE

Induction de la lactation chez des génisses ovariectomisées

Le but de cette expérience était de déterminer la possibilité de stimuler le développement de la glande mammaire et la production laitière de 30 génisses ovariectomisées après la deuxième chaleur post-pubertaire. Les traitements mis à l'essai consistaient en des injections de progestérone ou d'estrogène, ou des deux hormones combinées, pour des périodes de temps allant de 4 à 21 jours. La dexaméthasone était également étudiée. On déterminait le développement mammaire par palpation et par examen visuel. Enfin, on prélevait des échantillons de sang, pour mesurer les concentrations d'hormones, et des échantillons de fluide lactéal pour doser la teneur en protéine et en lactose.

L'examen préliminaire des données démontre que les injections de progestérone seule n'ont causé aucun développement de la glande mammaire et n'ont pas stimulé la sécrétion lactée. Toutefois, des neuf génisses qui recevaient de l'estrogène et de la progestérone, sept ont développé leur système mammaire et sécrété du lait. La dexaméthasone, qui devait accentuer les effets des stéroïdes sur la production lactée, a été sans effet. Il convient de souligner que ni le nombre d'injections de la progestérone et de l'estrogène, ni la durée des injections n'a pu changer les quantités de lait produites. Une période de 7 jours d'injections des deux stéroïdes a permis des productions similaires à celles obtenues avec des injections réparties durant des périodes de 12 à 21 jours.

La traite fut initiée en moyenne 22 jours après le début de la période d'injection des hormones. Une production moyenne de 1,69 kg par traite et par jour fut obtenue avec les génisses recevant les injections d'estrogène et de progestérone pendant 7 jours.

Le travail a été réalisé en collaboration avec des chercheurs de l'Université d'Ohio State. Ceux-ci détermineront le lactose et les protéines dans les sécrétions lactées, ainsi que les hormones dans le plasma sanguin.

Laits de substitution pour le veau

On a étudié les effets de quatre niveaux de graisses dans les laits de substitution pour le veau. Les laits contenaient 20, 26, 32 et 38% de graisses et la concentration en protéines brutes était gardée constante à 21% sur base de matière sèche. Durant une période de 77 jours, 16 veaux reçurent l'un des quatre laits reconstitués au taux de 17% en matière sèche et servi en deux repas égaux au taux journalier moyen de 2% du poids vif sur base de matière sèche. Le lait de substitution à 20% de graisse était un lait commercial et servait de témoin.

Les gains quotidiens moyens étaient de 0,81, 0,78, 0,86 et 0,70 kg et les conversions alimentaires, exprimées en kg de matière consommée par kg de gain, étaient de 1,60, 1,70, 1,58 et 1,80 pour les traitements à 20, 26, 32 et 38% de graisses respectivement. Dans le même ordre, les poids vifs à l'abattage étaient de 111,1, 107,8, 113,0 et 101,6 kg et les rendements de carcasses étaient de 54,3, 55,0, 54,2 et 56,7%.

L'augmentation de poids vif et la conversion alimentaire des veaux au lait à 32% de

graisses étaient significativement supérieures ($P < 0,05$) à celles des veaux au lait à 38% de graisses.

Les résultats indiquent que le lait de remplacement contenant 32% de graisses permet d'obtenir des taux de gain supérieurs à ceux obtenus des laits de remplacement contenant 20 et 26% de graisses. Puisque l'augmentation de graisses est faite aux dépens de la poudre de lait écrémé, la substitution est également avantageuse pour le fabricant, car, au prix actuel des denrées, les graisses sont moins dispendieuses que la poudre de lait.

Exigences en méthionine du veau

Afin de déterminer les exigences en méthionine du veau, une expérience a été réalisée avec 12 veaux mâles à qui on a servi des laits de remplacement contenant sept différents niveaux de méthionine. Une diète ne contenait que 50% du niveau de méthionine contenu dans le lait écrémé, tandis que les six autres contenaient 62,5, 75,0, 87,5, 100,0, 112,5 et 125,0% de ce même niveau.

L'expérience consistait en trois périodes de 12 jours au cours desquelles les veaux recevaient, pendant la période initiale de 5 jours, une ration déficiente en méthionine, suivie d'une période de 7 jours à l'une des six diètes contenant les quantités indiquées de méthionine.

Les quantités de matière sèche consommées étaient de 678, 701, 685, 719, 735, 747 et 718 g/jour pour les veaux recevant respectivement les sept diètes en commençant par la plus basse en méthionine. Dans le même ordre, la digestibilité de la matière sèche était de 83,4, 86,8, 88,3, 89,1, 90,0, 90,3 et 89,7%, la digestibilité de l'azote de 81,1, 85,0, 86,0, 87,2, 88,1, 89,3 et 85,8%, et la rétention de l'azote de 8,3, 9,7, 10,0, 11,5, 12,3, 14,4 et 12,1 g/jour. La concentration en groupements aminés libres dans le sang était également affectée par les traitements. Les niveaux étaient de 3,7 mmol/litre pour le groupe déficient en méthionine, et de 3,0, 3,6, 3,0, 2,6 et 2,6 mmol/litre pour les six niveaux respectifs de méthionine. Toutefois, les gains de poids vif ne suivaient pas la même tendance. Les veaux à la diète déficiente en méthionine accusaient un gain de 386 g/jour, alors que ceux aux six autres diètes réalisaient des gains de 250, 345, 274, 286, 298 et 298 g/jour.

Ces résultats indiquent que la consommation en matière sèche, la digestibilité de la matière sèche et de l'azote, ainsi que la rétention de l'azote sont accrues par l'addition de 1,1 g de méthionine à chaque kilogramme de lait de remplacement. S'il n'y a pas d'amélioration du taux de croissance, il est fort probable qu'il n'en dépend que de la trop courte période pendant laquelle les veaux recevaient la méthionine additionnelle.

Performance au premier vêlage de génisses croisées

Des génisses de boucherie \times laitières, provenant des croisements Charolais \times Holstein (CHo), Charolais \times Ayrshire (CA), Hereford \times Holstein (HeHo) et Hereford \times Ayrshire (HeA), pesaient au vêlage 437, 415, 402 et 360 kg respectivement, alors qu'elles étaient âgées en moyenne de 24 mois. Pendant les 182 jours d'allaitement qui suivaient le vêlage, les poids respectifs de ces quatre groupes de génisses changeaient de +2,6 kg, +20,8 kg, -4,8 kg et -16,5 kg.

Les génisses avaient été saillies artificiellement par un taureau Limousin ou un taureau Angus. Les veaux issus du Limousin étaient de 1,0 kg plus pesants à la naissance que ceux du Angus. Au sevrage, à l'âge de 182 jours, cette différence était de 9,0 kg, soit un avantage de 5,3% en faveur du croisement Limousin.

Les veaux provenant des génisses CHo pesaient 3,4 kg de plus à la naissance que ceux des génisses CA, et ceux des génisses HeHo, 3,6 kg de plus que ceux des génisses HeA. Au sevrage, les poids des veaux issus des génisses croisées Charolaises étaient en moyenne 3,5% supérieurs à ceux des veaux provenant des génisses croisées Herefords.

Bouvillons croisés mis en marché à divers poids

A quel poids devrait-on abattre des bouvillons croisés Charolais \times Holstein et Hereford \times Holstein pour qu'ils soient rentables et que la carcasse soit de qualité désirable? Pour le savoir, on en a abattu cinq de chaque croisement à 454 kg (1 000 lb), 544 kg (1 200 lb) et 635 kg (1 400 lb). Tous avaient été soumis au même régime alimentaire, dont la première phase favorisait la croissance et la seconde l'engraissement.

C'est au poids de 544 kg que les deux croisements ont rapporté le plus de profits,

les croisés Herefords étant un peu plus rentables que les croisés Charolais.

Les croisés Charolais ont fait un gain quotidien plus élevé que celui des croisés Herefords au cours de la première phase de la période alimentaire. Au cours de la deuxième phase, les Herefords ont accusé un léger avantage. Toutefois, si l'on considère la période alimentaire totale, les croisés Charolais ont pris 35, 33 et 32 jours de moins pour atteindre les poids de mise en marché de 454, 544 et 635 kg, comparativement aux croisés Herefords.

D'après les mesures corporelles prises sur les animaux vivants, les croisés Charolais étaient, en général, plus hauts, plus longs et plus larges à l'arrière-train que les croisés Herefords. Ceux-ci étaient plus profonds et plus larges à l'avant-train, aux poids de 454 et 544 kg.

Il y a eu très peu de différence dans le rendement de la carcasse entre les deux croisements aux trois poids de mis en marché.

En général, les croisés Charolais ont produit une viande plus maigre que celle des croisés Herefords. Par contre, les croisés Herefords ont déposé plus de gras en surface et à l'intérieur des muscles. En disséquant la 12^e côte, on a aussi obtenu un pourcentage d'os un peu plus élevé chez les croisés Charolais que chez les croisés Herefords. La quantité de graisse, au niveau de la noix de côte, n'a pas tellement augmentée avec le poids des croisés Charolais, alors qu'elle s'est accrue de façon significative avec l'augmentation de poids chez les croisés Herefords. Ceci explique, en partie, la supériorité de catégorie des carcasses et, par conséquent, la différence d'économie en faveur des croisés Herefords mis en marché aux poids de 544 et 635 kg.

Comparaison de l'activité oestrale des brebis

On a comparé 80 brebis, représentant les races Dorset, Leicester, Suffolk et le triple croisement de ces mêmes races (DLS), afin de déterminer la longueur de la période d'accouplement au cours d'une même année. Les brebis DLS avaient été sélectionnées en vue d'un agnelage hâtif de novembre et décembre. Pendant toute la durée du test, les brebis demeuraient dans des conditions normales d'éclairage et de température, et les signes de chaleur en étaient vérifiés journalièrement à l'aide de béliers vasectomisés.

Les brebis DLS et Dorsets ont commencé leur saison d'accouplement 46,4 et 35,5 jours avant les Leicesters, et 49,3 et 38,7 jours avant les Suffolks. La fin de la saison d'accouplement arrivait en moyenne le 10 mars pour les brebis DLS, date qui dépassait de 9,3, 23,0 et 45,4 jours la fin d'accouplement des brebis des races Dorset, Leicester et Suffolk, respectivement. La durée moyenne de la saison d'accouplement des brebis DLS était de 20 jours plus longue que celle des Dorsets, et 70 et 115 jours plus longue que celles des Leicesters et des Suffolks.

Nutrition et régie de truies en croissance

Le but de cette expérience était de déterminer l'influence du régime alimentaire et de la régie de la jeune truie pendant les mois d'hiver sur sa croissance et sa capacité de reproduction. On a utilisé des truies croisées pesant entre 14 et 60 kg au début de l'expérience. On les a assignées également à deux genres d'étables, soit une étable ouverte sur poteaux (environnement froid) et une étable fermée (environnement confortable). Dans chaque étable, on a servi à un tiers des truies une moulée de croissance à volonté, alors qu'on a servi aux autres 80% de la quantité de moulée consommée par le groupe nourri à volonté. Au poids de 95 kg, on a noté l'âge et l'épaisseur du gras dorsal, et on a projeté ce qu'aurait été le classement de la carcasse si l'animal avait été abattu.

Les résultats préliminaires semblent indiquer que l'environnement a eu très peu d'influence sur les caractères étudiés. Toutefois, le groupe nourri à volonté avait 10,2% plus de gras dorsal, perdait 3,9 unités de classement de carcasse et prenait 13 jours de moins pour se rendre à 95 kg que le groupe tenu à 80% de la consommation à volonté.

Après le premier oestrus, la moitié des truies à l'alimentation restreinte passait à une alimentation à volonté («flushing»). Toutes les truies étaient accouplées au deuxième oestrus.

Les truies élevées au froid produisaient 0,2 porcelet de plus par portée que celles gardées à l'environnement confortable, pour un poids supérieur par portée de 0,4 kg. Cependant, le taux de conception des premières était plus faible. Indépendamment de l'environnement, le groupe qui avait subi le «flushing» produisait 0,2 et 0,8 plus de porcelets par portée que le groupe nourri continuellement à volonté et

celui à 80% de la consommation à volonté, respectivement.

PRODUCTIONS VÉGÉTALES

Ensilage de maïs pour agneaux

Une variété de maïs semi-hâtive (P.A.G. SX48) a été récoltée le premier, le 15 et le 26 septembre, soit aux stades pâteux-mou, pâteux-dur et après-gel. Deux niveaux de finesse du hachage ont été obtenues en récoltant avec ou sans le sas recoupeur sur la fourragère.

La teneur en matière sèche de l'ensilage a été de 21,3, 26,3 et 27,8% pour les stades pâteux-mou, pâteux-dur et après-gel, respectivement. Ni la gelée avant la récolte, ni la finesse de hachage n'a influencé la composition chimique de l'ensilage. Par ailleurs, la maturité des grains à la récolte a grandement influencé la composition chimique de l'ensilage. C'est ainsi que du stade pâteux-mou au stade pâteux-dur la protéine est passée de 9,5 à 8,3%, les parois cellulaires de 65,0 à 53,4% et la lignocellulose de 37,0 à 28,2%.

La gelée avant la récolte a amélioré la digestibilité de la matière sèche, celle-ci étant de 61,2 et 65,5% pour les stades pâteux-dur et après-gel, respectivement. Quant à l'ensilage récolté au stade pâteux-mou, le hachage grossier comparé au hachage fin a augmenté la digestibilité de la protéine de 10%. Par contre, pour l'ensilage récolté après une gelée, le hachage grossier a diminué la digestibilité de 5% par rapport au hachage fin.

La consommation journalière en matière sèche, exprimée par kilogramme de poids métabolique, a été de 41,6, 57,0 et 57,9 g, et celle en énergie digestible de 127,7, 158,6 et 184,1 kcal pour les ensilages récoltés aux stades pâteux-mou, pâteux-dur et après-gel. La finesse du hachage n'a pas eu d'influence sur la consommation.

Propriétés physiques du sol et assimilation du manganèse et du cuivre

On a étudié les interactions entre la texture et l'aération du sol, et entre la couleur du sol et la température ambiante, en tant qu'elles influent sur l'absorption du cuivre (Cu) et du manganèse (Mn) natifs de certains sols.

Indépendamment de la texture, une augmentation de la diffusion de l'air a réduit les rendements en grain et en racines et la teneur en Mn de l'avoine, mais elle en a augmenté

la teneur en Cu. Dans tous les cas, cette diffusion de l'air a diminué d'une façon très significative le Cu et le Mn échangeable du sol. On a constaté, d'une texture à une autre du sol, des variations marquées du Cu et du Mn échangeable, ainsi que du Mn réductible.

La teneur en Mn de l'avoine provenant de sols de neuf couleurs différentes s'est avérée plus élevée à une température ambiante de 27°C qu'à 15°C. On a pourtant observé le contraire pour ce qui est des rendements et de la teneur en Cu. Indépendamment de la couleur du sol, une corrélation significative existait entre le Mn échangeable du sol et la température de la serre. Parmi les sols des neuf couleurs, les différences de rendements et de teneurs en Cu et en Mn de l'avoine ont été très significatives.

Gangue d'amiante pour la culture de la luzerne

L'extraction de l'amiante laisse des quantités énormes de résidus, ou gangue, qui s'accumulent en de véritables montagnes. Or, on sait que ces résidus contiennent environ 37% de magnésie (MgO) dont une partie seulement est facilement assimilable par les plantes; il faudrait donc l'appliquer à des doses comparables à celles de la pierre à chaux pour faire des apports significatifs de magnésie au sol. Si la gangue d'amiante, dont le pH est de 9,15, avait quelque valeur comme amendement du sol, on pourrait alors l'utiliser en agriculture et contribuer ainsi à la disparition de ces immenses amas qui nuisent à la qualité de l'environnement.

Nous avons donc comparé la gangue de minéral d'amiante à la pierre à chaux calcique et au carbonate de magnésium comme amendement du sol en vue de la culture de la luzerne.

Dans une première expérience, nous avons mélangé au sol, un loam limoneux de Coaticook de pH 5,0, chacun des trois amendements suivants: pierre à chaux calcique, carbonate de magnésium et gangue d'amiante. Les doses variaient de 0 à 20,6 t/ha (de 0 à 10 tonnes/ac). La différence d'une dose à l'autre était de 2,42 t/ha et nous avons onze points dans la courbe. Nous avons ajusté le pourcentage de l'eau du sol à la capacité au champ et l'avons maintenu à ce niveau pendant toute la période d'incubation, soit un an.

L'addition de gangue d'amiante au sol ne l'a pas neutralisé. Après une période d'incubation de 45 jours, le pH du sol est passé de 5,0 à 5,35. Le prolongement de la période à un an ne l'a pas accru davantage. Il a quand même fallu une application de gangue d'amiante à un taux de 20,63 t/ha pour obtenir ce degré de neutralisation du sol. La même dose de pierre à chaux calcique a porté le pH du sol à 7,48 et celle de carbonate de magnésium l'a élevé à 8,32.

La gangue d'amiante a cependant accru la teneur en magnésium échangeable du sol de 0,6 à 2,0 meq/100 g de sol. L'addition de chaux calcique a légèrement diminué la magnésie échangeable du sol tandis que le carbonate de magnésium à la dose de 20,63 t/ha a augmenté la teneur en Mg échangeable de 0,5 à 10,6 meq/100 g de sol.

En même temps que s'effectuait l'incubation du sol, une autre expérience recherchait la valeur de ces mêmes amendements du sol appliqués à des doses semblables pour la culture de la luzerne. On a fait sept coupes de cette légumineuse cultivée en serre. L'incorporation au sol de la gangue d'amiante à 33 t/ha (15 tonnes/ac) a produit un rendement de luzerne de 43 g de matière sèche par pot, comparé à 0,03 g dans le sol témoin; pourtant le pH du sol traité au résidu de minéral d'amiante n'était que de 5,2. La teneur en magnésium échangeable est passée de 0,629 à 3,860 meq/100 g. Cette augmentation en magnésium échangeable a permis d'obtenir un rendement de luzerne atteignant 66% de la normale en dépit d'un pH de 5,2.

Il ressort que l'utilisation de la gangue d'amiante, même en quantité massive, n'a pu neutraliser l'acidité du sol, mais a fourni quand même assez de magnésium échangeable pour permettre à la luzerne une croissance atteignant 66% de la normale.

Influence du dalapon et des éléments N, P, K sur des légumineuses fourragères

Un projet, destiné à améliorer le contenu en légumineuses des prairies et des pâturages sans travail du sol, a été initié en 1972.

La phase initiale, maintenant achevée, consistait à étudier la germination sur papier filtre des semences en contact avec des quantités de dalapon et de N, P et K

correspondant à des applications de dalapon aux taux de 0 et 40 kg/ha, d'azote à 0, 20 et 40 kg/ha, de phosphore à 0, 40 et 80 kg/ha ainsi que de potassium à 0, 20 et 40 kg/ha. Tous ces traitements, combinés selon un dispositif factoriel, ont été appliqués à deux semis différents effectués en pots et en serre.

Les résultats de l'essai de germination ont indiqué que l'équivalent de 40 kg/ha de dalapon 12,5 G étendu sur buvard a réduit de moitié la germination du trèfle ladino et du lotier, tandis que la luzerne n'en était pas affectée. L'addition d'engrais à tous les niveaux a affecté d'une façon encore plus marquée que le dalapon la germination des trois espèces étudiées. De façon générale, la germination diminuait avec l'accroissement de la concentration du milieu en sels solubles.

Le dalapon a réduit les populations de luzerne et de trèfle blanc d'environ 10% et leur croissance, mesurée par la production de matière sèche à 6 semaines, de 50%. Il n'a affecté ni la population ni la croissance du lotier. On a observé des réductions du nombre de nodules chez les trois espèces étudiées lorsque traitées au dalapon. Les apports d'azote n'ont pas modifié de façon significative la production par unité de surface, cependant, les plantules de lotier étaient significativement mieux développées là où il y avait des applications de N équivalant à 40 kg/ha.

L'addition de phosphore à 40 kg/ha n'a produit aucune augmentation de rendement chez la luzerne, cependant, 80 kg/ha ont haussé de 50% le poids des plants récoltés. Le phosphore à 40 kg/ha a permis un accroissement de 10% de poids chez le lotier tandis qu'aucun effet n'a été observé chez le trèfle blanc. On a observé une plus grande nodulation des plants de luzerne lorsque des apports de phosphore ont été effectués.

L'addition du potassium n'a pas eu d'effet significatif chez la luzerne et le lotier, par contre, chez le trèfle blanc des quantités de 30 kg/ha ont suffi à diminuer significativement le nombre de plants, et 40 kg/ha ont causé des retards dans la croissance caractérisés par des poids de 50% inférieurs à ceux des plants ne recevant pas de potassium. De façon générale, la nodulation des plantes des trois espèces diminuait à mesure que les concentrations de N et de K augmentaient.

PUBLICATIONS

Recherches

- Bernard, C. S., Fahmy, M. H. et Lalande, G. 1973. The influence of age at first calving and winter feeding management as yearlings on calf production from beef Shorthorn cows. *Anim. Prod.* 17:53-58.
- Bouchard, R., Brisson, G. J. et Julien, J. P. 1973. Nutritive value of bacterial sludge and whey powders for protein in calf milk replacers and on chromic oxide as indicator of digestibility. *J. Dairy Sci.* 56:1445-1449.
- Bouchard, R. et Conrad, H. R. 1973. Sulfur requirement of lactating dairy cows. I. Sulfur balance and dietary supplementation. *J. Dairy Sci.* 56:1276-1282.
- Bouchard, R. et Conrad, H. R. 1973. Sulfur requirement of lactating dairy cows. II. Utilization of sulfate, molasses and lignin-sulfonate. *J. Dairy Sci.* 56:1429-1434.
- Bouchard, R. et Conrad, H. R. 1973. Sulfur requirement of lactating dairy cows. III. Fate of sulfur-35 from sodium and calcium sulfate. *J. Dairy Sci.* 56:1435-1438.
- Bouchard, R. et Conrad, H. R. 1973. Supplementary value of hydroxy analog of methionine and sulfates in diets of lactating cows. *J. Dairy Sci.* 56:665.
- Fahmy, M. H. et Bernard, C. S. 1973. Effects of crossbreeding and certain environmental factors on multiple births, wool production and growth in sheep. *Anim. Prod.* 16:147-155.
- Fahmy, M. H. et Lalande, G. 1973. Genetic and environmental trends in preweaning performance of Shorthorn calves. *Can. J. Anim. Sci.* 53:637-640.
- Genest, J. et Steppler, H. 1973. Effects of companion crops and their management on the undersown forage seedling environment. *Can. J. Plant Sci.* 53:285-290.
- Laflamme, L. F. 1973. Biopsy sampling for growth studies in cattle. *Can. J. Anim. Sci.* 53:193-194.
- Laflamme, L. F. et Burgess, T. D. 1973. Effect of castration, ration and hormone implants on the performance of finishing cattle. *J. Anim. Sci.* 36:762-767.
- Pelletier, G. 1973. Influence de certaines méthodes de fenaison et de conservation sur la qualité d'un mélange fourrager. *Nat. Can. (Qué.)* 100:385-393.
- Pelletier, G. et Donefer, E. 1973. Nutritive value of fresh and dried marrowstem kale harvested at two different periods. *Can. J. Anim. Sci.* 53:257-263.
- Pelletier, G. et Martin, L. J. 1973. The blood picture of sheep fed on fresh and dried marrowstem kale. *Can. J. Anim. Sci.* 53:229-236.

Divers

- Bernard, C. S., Fahmy, M. H. et Lalande, G. 1973. Effects of early calving and winter nutrition on lifetime production. *Canadex* 420.10.
- Bouchard, R. 1973. Inorganic sulfur is most effective in dairy rations. *Feedstuffs*, July 2:20.
- Bouchard, R. 1973. Sulfur requirement of lactating dairy cows. *Canadex* 410.53.
- Bouchard, R. et Conrad, H. R. 1973. Determination of the most limiting amino acid for dairy using plasma acid concentrations. *Fed. Proc.* 32:905.
- Bouchard, R. et Conrad, H. R. 1973. Sulfur requirements of lactating dairy cows. *Ohio Herd Improv. Obs.* Aug.
- Conrad, H. R. et Bouchard, R. 1973. Sulfur requirements of dairy cows. *Ohio Rep. Res. Develop.* 58:102-103.
- Conrad, H. R., Bouchard, R. et Hibbs, J. 1973. High fiber urea supplemented diets in dairy cows. *Rumen Funct. Conf. (Nutr.)* Nov.
- Dufour, J. 1973. Chemical shearing of sheep. *Canadex* 430.26.
- Fahmy, M. H. 1973. Swine crossbreeding research at Lennoxville. Will it answer any of your questions? *Can. Swine* 47(19):22-25.
- Fahmy, M. H., Bernard, C. S. et Lemay, J. P. 1973. Southdown vs Suffolk rams as sires of light and heavy market lambs. *Canadex* 430.35.
- Fahmy, M. H. et Lalande, G. 1973. Daily gain and feed efficiency in beef \times dairy crosses. *Canadex* 420.50.
- Flipot, P., Lalande, G. et Fahmy, M. H. 1973. Cold milk replacer for calves. *Canadex* 410.60.
- Genest, J. 1973. Qui veut économiser \$581.00 de luzerne? *Can. Agric.* 18(2):22-23.

Station de recherches Sainte-Foy, Québec

CADRES PROFESSIONNELS

S. J. BOURGET, B.Sc. (Agr.), M.S., Ph.D.	Directeur
C. GAGNON, B.A., B.Sc. (Agr.), M.Sc., Ph.D.	Directeur adjoint
J. R. FRAPPIER, B.A.	Services administratifs

Support scientifique

P. VENNE, B.Bibl., M.L.S.	Bibliothèque
---------------------------	--------------

Amélioration des plantes

H. GASSER, B.S.A., M.Sc., Ph.D.	Chef de la section; plantes fourragères
M. R. BULLEN, B.Sc. (Agr.), M.Sc., Ph.D.	Génétique des plantes fourragères
J. M. DESCHÊNES, B.Sc. (Agr.), M.Sc., Ph.D.	Écologie
J. P. DUBUC, B.Sc. (Agr.), Ph.D.	Céréales
R. MICHAUD, B.Sc. (Agr.), M.Sc.	Génétique des légumineuses
E. ROCHAT, Ing. agron., M.Sc., D.Sc.	Amélioration des graminées
C. A. ST-PIERRE, B.Sc. (Agr.), M.Sc., Ph.D.	Céréales
J. C. ST-PIERRE, B.Sc. (Agr.), M.Sc., Ph.D.	Physiologie des plantes fourragères

Physiologie des plantes

R. PAQUIN, B.A., B.Sc. (Agr.), M.Sc., Ph.D.	Chef de la section; survie à l'hiver
R. BOLDUC, B.A., B.Sc. (Agr.), Ph.D.	Résistance au froid, cytologie
H. J. HOPE, B.Sc., M.Sc., Ph.D.	Résistance au froid, mécanisme
C. WILLEMOT, B.S.A., M.Sc., Ph.D.	Résistance au froid, mécanisme

Phytoprotection

C. GAGNON, B.A., B.Sc. (Agr.), M.Sc., Ph.D.	Chef de la section; maladies des légumineuses
A. COMEAU, B.Sc., Ph.D.	Entomologie
G. PELLETIER, B.A., B.Sc. (Agr.), M.Sc., Ph.D.	Maladies des céréales

C. RICHARD, B.Sc., M.Sc., D.Sc.
J. SANTERRE, B.A., B.Sc., M.Sc.

Maladies des légumineuses
Nématologie

Sols

C. DE KIMPE, B.A., Ing. Chim. et Ind. agr.,
D.Sc.

Chef de la section; genèse

L. BORDELEAU, B.Sc. (Agr.), M.Sc., Ph.D.

Microbiologie

M. LAVERDIÈRE, B.Sc. (Agr.), M.Sc.

Pédogénèse et minéralogie

Y. MARTEL, B.Sc. (Agr.), Ph.D.

Chimie et fertilité

J. ZIZKA, B.A., B.Sc. (Agr.), M.Sc.

Fertilité

Économie

J. V. LEBEAU¹, B.S.A., M.Sc.

Rentabilité

C. FALGON¹, Ing. agron.

Rentabilité

Ferme expérimentale, La Pocatière

J. E. COMEAU, B.Sc. (Agr.), M.Sc.

Régisseur

G. BARNETT, B.Sc. (Agr.), M.Sc.

Sols

L. BELZILE, B.Sc. (Agr.), M.Sc.

Plantes fourragères

H. GÉNÉRÉUX, B.A., B.S.A., M.Sc.

Maladies des pommes de terre

R. RIOUX, B.A., B.Sc. (Agr.)

Herbicides et cultures spéciales

Ferme expérimentale, Normandin

J. P. F. DARISSE, B.A., B.Sc. (Agr.), M.Sc.

Régisseur

R. DRAPEAU, B.Sc. (Agr.), M.Sc.

Plantes fourragères

SCIENTIFIQUE INVITÉ

R. J. WILLIAMS, B.Sc., M.S., Ph.D.

Biochimie

Blood Research Laboratory, Bethesda, Md, U.S.A.

¹Détaché de la Direction de l'économie du ministère de l'Agriculture du Canada.

INTRODUCTION

Cette publication représente un résumé des principaux résultats de recherches obtenus en 1973 à la Station à Sainte-Foy et aux deux fermes expérimentales satellites de La Pocatière et Normandin.

Toute demande de renseignement ou de tirés-à-part doit être adressée à: Station de Recherches, Agriculture Canada, 2560 Chemin Gomin, Sainte-Foy, Qué. G1V 2J3.

S. J. Bourget
Directeur

LES PLANTES

Plantes fourragères

Une étude ayant pour but de déterminer les rendements de la fléole des prés communément appelée mil, de la luzerne et du trèfle rouge semés séparément ou en mélanges a été poursuivie à trois sites différents.

A La Pocatière, les rendements de matière sèche (m.s.) ont été très élevés en 1972 pour une année de semis; ainsi, la luzerne a fourni 6 085 kg de m.s. par hectare et le mil, 4 918 kg/ha. Des variétés de mil, Clair a été supérieure à Climax et à Bounty en donnant 4 521 kg de m.s./ha contre 3 295 et 3 218 kg/ha pour les deux autres respectivement. Aucun traitement différentiel n'avait été appliqué; donc, la différence était due à la variété seulement.

A St-Augustin, on a fait une seule coupe en 1972, l'année du semis. La luzerne a donné 4 133 kg de m.s./ha et le mil, 4 337 kg/ha. A l'inverse de La Pocatière, les variétés Climax et Bounty, en rendant 4 386 et 4 374 kg de m.s./ha respectivement, ont surclassé Clair, qui a donné un rendement de matière sèche de 3 910 kg/ha. En 1973, deux coupes ont été effectuées avant l'automne sur toutes les parcelles sauf celles du trèfle rouge en semis pur qui ont dû être réensemencées. Le mil a eu un rendement de matière sèche de 7 432 kg/ha et la luzerne, 6 486 kg/ha. Une troisième coupe a été prélevée après la première gelée mortelle. Bounty a été la variété de mil la plus productive à la première coupe.

Suite à une seule coupe également en 1972 à Normandin, le trèfle rouge en semis pur et en mélange a donné un rendement d'environ 3 260 kg/ha. La luzerne semée seule a fourni 2 866 kg de m.s./ha et associée au mil, 2 808 kg/ha. Le mil en semis pur a donné 2 629 kg de m.s./ha. Dans l'essai variétés de mil vs taux d'azote, Clair a eu un rendement de

1 493 kg/ha, Climax 1 376 kg/ha et Bounty 1 289 kg/ha. On a pris trois coupes sur toutes les parcelles en 1973 et aucun resemis n'a été effectué. A la première coupe, le mil a donné 3 581 kg de m.s./ha et la luzerne, 2 584 kg/ha. Le trèfle rouge avait une production intermédiaire d'environ 3 000 kg/ha. Climax était la variété de mil la plus productive à la première coupe.

Essai de variétés. En 1972, 43 variétés de ray-grass annuel ont été ensemencées au mois de juin à Normandin. Certaines variétés ont donné deux coupes et les rendements de m.s. s'évaluaient de 7 027 à 4 133 kg/ha. En 1973, 22 variétés de ray-grass annuel et 73 variétés de ray-grass vivace ont été ensemencées au mois de mai à Normandin. Deux coupes ont été effectuées mais aucun résultat n'est encore disponible. Trente-sept variétés de fétuque des prés ont été ensemencées en 1972 et aucune récolte n'a été prélevée durant l'année du semis. En 1973, sous un régime de pâturage et après deux coupes, les rendements de matière sèche vont de 4 097 à 2 222 kg/ha. La variété Fétila a été détruite par l'hiver 1972-73.

Hespérie européenne. L'hespérie européenne, *Thymelicus lineola* (Ochs.), étend maintenant son aire de distribution à la région de Montréal, de l'Outaouais, de l'Abitibi, de Québec et du bas St-Laurent. L'infestation semble devenir critique près de Joliette. Au Lac St-Jean, les dégâts de 1973 ressemblent à ceux de 1972. Nous avons recueilli des données préliminaires sur la biologie de l'hespérie au Lac St-Jean, où 80% du dommage au mil a été causé entre le 18 juin et le 1^{er} juillet 1973. On note une mortalité significative des larves et des pupes vers la fin de juin, mais cette mortalité semble arriver trop tard pour contribuer à réduire le dommage. Certains types de plants de mil semblent préférés à d'autres pour

l'oviposition. Aucun parasite européen *Stenichneumon scutellator* (Grav.) n'a été reçu en 1973. Le parasite *Phryxe vulgaris* (Fallén) est encore en élevage, mais des lâchers n'ont pu être effectués.

Rhizobium meliloti. Nous avons évalué le comportement fixateur de l'azote atmosphérique chez 49 souches de *R. meliloti* avec la variété de luzerne Saranac. Six souches ont manifesté un grand pouvoir fixateur et provoquent des rendements moyens chez la luzerne Saranac nettement supérieurs à ceux des plantes fertilisées à l'azote minéral. Il existe une spécificité des souches vis-à-vis la variété Saranac, ou bien il y a stimulation de l'activité fixatrice des souches isolées de la variété Saranac, stimulation provenant de la plante elle-même; ces effets diminuent avec le temps. Nous sommes à étudier l'écologie des meilleures souches, la stabilité de leurs caractères, ainsi que leur persistance sous les conditions climatiques du Québec. Le comportement fixateur d'un mélange de souches très efficaces au départ avec des souches très efficaces après deux et trois coupes de la luzerne nous indique qu'un tel mélange serait souhaitable dans l'établissement d'une luzernière.

Dans ce projet, nous cherchons aussi à économiser du temps par des méthodes de pré-sélection de souches efficaces nous permettant de manipuler le plus grand nombre possible de souches, sans avoir à toutes les vérifier avec la plante; la sélection finale se fait évidemment sur la plante. Nous avons trouvé une corrélation positive entre l'efficacité symbiotique des souches et les changements dans le pH du milieu lorsque les bactéries sont cultivées *in vitro*. Toutes les souches abaissant le pH à un niveau inférieur à 6,0 sont inefficaces et peuvent être éliminées, tandis que celles qui changent le milieu à un pH de 6,25 à 7,2 sont efficaces. Ainsi, cette méthode nous permet de sélectionner rapidement des souches efficaces. Des résultats préliminaires nous indiquent qu'il y a une corrélation négative entre le métabolisme oxydatif du *Rhizobium* en culture *in vitro* et sa capacité symbiotique à fixer l'azote; cette nouvelle méthode nous permet d'éliminer un grand nombre de souches inefficaces. La combinaison séquentielle de ces deux méthodes, suivie de la sélection sur la plante, nous permettra de manipuler des centaines de souches dans un temps relativement court.

Nous avons aussi évalué la capacité symbiotique des inoculants commerciaux des légumineuses, tels qu'ils sont distribués aux cultivateurs. Ce projet s'est établi en collaboration avec le Département d'Agrobiologie de l'Université Laval. Il appert qu'environ 75% des inoculants distribués aux cultivateurs n'ont aucune valeur, soit à cause du trop petit nombre de *Rhizobium* viables par sachet d'inoculant ou de leur manque de spécificité; ceci est probablement dû à un mauvais entreposage d'une part, et à l'utilisation des souches non adaptées d'autre part.

Nématologie. Nous avons continué en 1973 l'enquête entreprise au Québec en 1971 afin d'acquérir une meilleure connaissance des types de nématodes parasites des plantes associés aux principales légumineuses fourragères dans l'est du Canada. Après avoir parcouru, durant l'été 1973, 441 ha de champs fourragers dans 29 comtés, nous avons recueilli 131 échantillons de sol et de racines répartis comme suit: luzerne: 54; trèfle rouge: 74; lotier: 3. L'analyse de ces échantillons se fait présentement à notre Station. Les premiers résultats de l'analyse montrent les fréquences suivantes des différents types de nématodes extraits des échantillons de sol et de racines:

SOL:

Pratylenchus, 92%
Paratylenchus, 68%
Criconemoides, 49%
Heterodera et *Meloidogyne*, 36%
Helicotylenchus, 27%
Tylenchorhynchus, 9%

RACINES:

Pratylenchus, 64%
Meloidogyne, 30%
Heterodera, 20%
Paratylenchus, 16%
Helicotylenchus, 8%
Criconemoides et *Tylenchorhynchus*, 2%

A ce jour, environ 90% de la superficie totale de foin cultivée au Québec, luzerne, trèfle rouge et lotier, ont été inventoriés.

Tolérance au froid

La luzerne. Une étude des effets de l'âge de la plante sur son endurcissement au gel a montré que c'est à l'âge de 5 à 6 semaines qu'elle s'endurcit le plus. A cet âge, le taux de survie atteint 90 à 92%; à l'âge de 7 à 9 semaines, il atteint 81 à 82%, à l'âge de 15 semaines il est de 62% et à 17 semaines de moins de 50%. A 3 semaines, le pourcentage de survie est encore plus faible. L'effet de la durée de l'endurcissement sur la résistance au gel de la plante est aussi important et les résultats indiquent que la luzerne atteint un maximum d'endurcissement après 11 à 14 jours à $-1,5^{\circ}\text{C}$. Une étude sur la nécessité des parties aériennes de la plante pour effectuer son endurcissement a montré que sans les feuilles, l'endurcissement est impossible. Cependant, tout le feuillage ne serait pas nécessaire pour atteindre un maximum d'endurcissement et la partie inférieure du feuillage serait plus efficace que la partie supérieure.

Changement dans les lipides. Nous avons poursuivi l'étude de la synthèse des lipides au cours de l'endurcissement artificiel de deux variétés de luzerne (Rambler, rustique et Caliverde, tendre). Les analyses de masse et les marquages à partir d'acétate- $1,2\text{-}^{14}\text{C}$ montrent qu'au cours de l'endurcissement il y a synthèse accrue de lipides et d'acide linoléique chez les deux variétés; cette stimulation de la synthèse est beaucoup plus forte chez Rambler, qui produit surtout des phospholipides, en particulier de la phosphatidylcholine, que chez Caliverde qui produit surtout des triglycérides.

Chez le blé, contrairement aux résultats obtenus de la luzerne, le marquage des acides gras et de la phosphatidylcholine au carbone- 14 , ainsi que des phospholipides au phosphore- 33 , au cours de l'endurcissement artificiel ne semble indiquer que peu ou pas de différences variétales entre la variété tendre Champlain et la variété résistante Kharkov. Au niveau de la synthèse de l'élément lipidique des lipoprotéines des membranes du blé (lipides des protéines insolubles et de leurs lavages à l'acétone), il semble également y avoir peu de différences variétales.

Physiologie de la résistance. L'étude physiologique de certains aspects de la résistance à la gelée a donné les résultats préliminaires suivants: la perte de résistance à la gelée est très rapide au cours de la germination (5

heures pour la luzerne, 10 heures pour le blé); la perte de résistance au cours du désendurcissement est également très rapide: chez la luzerne, deux jours de désendurcissement à 20°C et 16 heures de jour suffisent pour éliminer la moitié de la résistance acquise au cours d'un mois d'endurcissement; les semences de luzerne les plus lentes à germer semblent donner les plantules résistant le mieux à la gelée.

Les céréales

Une étude a été débutée afin d'évaluer l'influence des conditions du sol et des mauvaises herbes sur le rendement des céréales. En serres, les types de sol (Kamouraska-St-André-Du Creux) et la compétition des mauvaises herbes ont influencé les rendements de l'orge et de l'avoine. Les faibles températures de sol ont retardé la maturité des céréales. Le gel du sol a eu un effet négligeable sur le nombre et le poids des grains, mais a diminué considérablement le chiendent.

Des expériences effectuées au champ au cours de l'été 1973 ont démontré que le gel du sol n'avait pas d'effet significatif sur le rendement des céréales et sur le poids total de matière sèche des mauvaises herbes. Cependant, sur une base d'espèces, le gel du sol a considérablement réduit le poids du chiendent et augmenté le poids de l'ortie royale, du tabouret et du chou gras. Le rendement des céréales a été plus élevé sur le sol Kamouraska que sur le sol St-André. Une grande partie de cette variation est attribuée aux mauvaises herbes, qui étaient plus abondantes sur le sol St-André. Le semis tardif (5 juin) a donné des rendements de céréales plus faibles que le semis hâtif (9 mai) sur les deux types de sol.

L'avoine

Évaluation. Dans les essais coopératifs de l'est du Canada, quatre lignées ont été évaluées quant à leur potentiel de rendement et autres qualités. Une de ces lignées a été rejetée à cause de son rendement déficient et deux autres demeureraient dans l'essai pour une évaluation plus poussée. La quatrième lignée (Q.O. 115.1.2.), ayant donné un rendement égal à ceux des meilleurs témoins avec une maturité plus hâtive, tout en maintenant les qualités essentielles, a été conservée et a reçu le support du «Canada Committee on Grain Breeding» dans le but

d'obtenir une demande de licence. Une étude pathologique déterminera si la lignée a une tolérance accrue au *Septoria*. Si les résultats en sont positifs, la demande sera faite de la promouvoir variété sous le nom d'Alma; elle pourra ainsi être vendue dans le commerce aux producteurs et aux consommateurs. A cet effet, quelque 1 400 kg (3 000 lb) de semence de Sélectionneur ont été produites sous des conditions strictes de surveillance.

Amélioration. Quelque 230 croisements ont été réalisés en 1973 pour répondre aux objectifs du Québec et des provinces Maritimes, en plus de quelques objectifs spéciaux tels que la hâiveté et la grosseur du grain. Quelque 200 croisements en ségrégation (F_2 à F_5) ont été sélectionnés pour la hâiveté, le rendement et la résistance de la paille, ainsi que pour les caractéristiques qualitatives du grain déterminées en laboratoire. Vingt-trois lignées provenant de neuf croisements différents ont été évaluées dans le cadre du Groupe du Québec. Un croisement a été éliminé tandis que 17 lignées provenant de huit croisements ont été retenues pour une évaluation plus poussée. Vingt-et-une lignées provenant de cinq autres croisements sont entrées en première année d'évaluation.

Trente croisements ont fourni 50 000 grains F_2 dont la moitié a été sélectionnée en serres pour la résistance au BYDV (nanisme jaune de l'orge), ce qui a donné 1 000 lignées F_3 qui ont été évaluées en champs pour la résistance au BYDV et pour certains caractères agronomiques. Une évaluation de la résistance des lignées commerciales se poursuit.

Septoriose. Comme il n'existe aucun cultivar d'avoine résistant à *Septoria avenae* Frank, moyen le plus économique de lutte, il importe de rechercher d'autres moyens de prévenir les pertes causées par cette maladie. De là, l'utilité de rechercher une substance fongicide adéquate. Nous avons donc entrepris de faire l'évaluation relative de différents produits fongicides systémiques et non systémiques. Parmi la gamme des produits essayés, nous avons décelé une action très efficace du benomyl et du thirame par la méthode de culture sur gélose. Par contre, d'autres produits fongicides, tels que le zinèbe, se révèlent plutôt inefficaces à éliminer le *Septoria* d'après cette méthode. Par la culture sur segments de feuilles d'avoine, on constate l'inefficacité surprenante du

thiophanate-méthyle, dépassant même celle du zinèbe.

L'orge

Évaluation. La variété d'orge Loyola a été ajoutée à la liste des variétés recommandées pour le Québec. Un peu plus hâtive et à meilleure paille que les variétés Conquest et Champlain, elle se situe entre les deux au point de vue rendement. Une interaction entre 16 variétés de céréales et les dates de semis a été observée en 1971 et 1972 à La Pocatière. Chez l'orge, la variété Champlain s'est montrée très stable tandis que Bonanza, Parkland et Conquest montraient de grandes variations entre leurs rendements en semis hâtif et tardif.

Amélioration. Un essai d'observation sur 30 lignées de notre programme a été établi à trois stations en 1973. Une technique de sélection de plants sur table permet à deux sélectionneurs d'évaluer pas moins d'un million de plants en moins d'un mois de sélection. Un système de boîtes nous permet d'identifier une seule enveloppe par croisement, tout en conservant la séquence complète de 15 000 plants sélectionnés. Ce procédé a été appliqué à 162 populations F_2 et environ 150 populations F_3 de croisements différents.

Vingt-cinq croisements ont fourni 40 000 grains F_2 qui ont été inoculés de BYDV et sélectionnés pour la résistance à cette maladie virale transmise par des pucerons. On a étudié l'effet de l'inoculation tardive du BYDV sur des lignées à bon potentiel agronomique.

LES SOLS

Caractérisation

Profils à horizons indurés. On a continué cette année l'étude des sols à horizons indurés situés dans les Appalaches par l'échantillonnage et l'analyse des séries Chapais, Painchaud et Chabot dans la partie ouest de leur zone de répartition, là où ces séries s'insèrent entre les caténas des séries Arago et St-Onésime. Dans cette région, le relief plus accentué n'a pas permis le développement de sols très profonds et souvent les caractères typiques du fragipan sont moins marqués. En conséquence, les sols ressemblent plus à ceux des autres caténas. Nous avons aussi échantillonné un sol Arago

profond dans lequel on a atteint le till non touché par les phénomènes d'induration. A 2,5 m (8 pi) environ, les fentes de retrait caractéristiques ainsi que la « fragilité » disparaissent. La densité et la compacité du till cependant demeurent les mêmes.

Il est donc intéressant de faire une comparaison entre les caractères micromorphologiques et les taux de porosité, comme cela fut fait pour un profil à Robertsonville. Alors que, dans les horizons supérieurs, le diamètre moyen des pores se situait aux environs de 25 μm , il s'est réduit à 0,5 μm dans le pan. Ceci aide à comprendre les restrictions évidentes au passage des racines et de l'eau.

Ce sont des phénomènes du même genre que ceux observés sur les terrasses du St-Laurent, lorsque des schistes, en profondeur, se décomposent et entraînent un colmatage d'horizons inférieurs des profils.

Séries à drainage déficient. L'étude des caténas Mistouc (séries Mistouc, Normandin, Albanel) et Larouche (séries Larouche, Chicoutimi, Hébertville), échantillonnées dans la région du Lac St-Jean, s'est poursuivie au cours de la première partie de l'année, l'emphase étant mise sur certaines propriétés physiques.

La texture des différents horizons variait du loam limono-argileux à l'argile. Les valeurs maximales de densité apparente ont été déterminées au niveau des horizons B (1,94 g/cm^3 pour l'horizon Bgf de la série Hébertville). Les pourcentages de rétention en eau, obtenus pour les échantillons soumis à différentes pressions (1/3 et 15 atm), ainsi que les pourcentages d'agrégats stables, étaient inférieurs dans ces mêmes horizons B. Des essais ont également été effectués en vue de déterminer la conductivité hydraulique des différents horizons. Les teneurs en matière organique varient de 4,5 à 18% dans les horizons A et décroissent rapidement à moins de 1,5% dans les horizons B sous-jacents. Les taux de saturation en bases se situent à 100% dans tous les horizons. Les valeurs en Fe-dithionite, Fe-oxalate et Fe-pyrophosphate diminuent avec la profondeur, certaines accumulations étant cependant notées pour le Fe-dithionite des horizons Bg (Chicoutimi) et Bgf (Hébertville).

FERME EXPÉRIMENTALE LA POCATIÈRE

Plantes fourragères

Fertilisation. Le phosphore et l'azote ont plus souvent augmenté le rendement des graminées que le potassium; l'azote a donné des augmentations plus fréquentes que le phosphore. Les formes de N (NH_4NO_3 , urée et urée-soufre) appliquées aux graminées, une ou trois fois par année, ont provoqué des effets positifs. A faible dose, NH_4NO_3 a été le plus efficace. A forte dose, l'urée et l'urée-soufre ont été supérieures au NH_4NO_3 . Les effets résiduels des placements de P sur la luzerne ont été minimes. Cependant, la luzerne a profité des apports d'engrais azotés.

Régie. Les semis d'août 1972 ont très bien survécu à l'hiver et le rendement diminuait lorsqu'on retardait la date de semis. Il y a eu peu de différence entre les rendements suivant les dates et les taux de semis variés du printemps 1973. La luzerne et le mil semés en association (rangs alternés) et en mélange ont donné de meilleurs rendements que les semis purs. La luzerne coupée après la gelée semble produire un peu moins l'année suivante.

Les céréales

Date et mode de semis. La préparation du sol à l'automne permet un semis plus hâtif, mais elle doit être suivie d'un léger hersage au printemps. Le type et le temps de ce hersage n'ont eu que peu d'influence sur les rendements, mais ont pour fonction essentielle la destruction des mauvaises herbes. Même avec une plus grande quantité de mauvaises herbes, le semis hâtif est le plus producteur. L'orge semble plus sensible à la compétition si elle est semée tardivement.

Fumure. La fertilisation à l'azote et au phosphore a été plus profitable avec le semis hâtif. Quant au semis tardif, le placement du phosphore avec la semence a augmenté le rendement sur l'argile Kamouraska et l'a réduit sur le loam St-André. Appliqué à la volée, le phosphore a été plus efficace sur le loam St-André que sur l'argile Kamouraska. En bande, le phosphore a été efficace sur les deux types de sol.

Les pommes de terre

Mode de culture. Un buttage à 5% de levée des pommes de terre a permis une bonne répression des mauvaises herbes sans l'addition d'herbicide. Par contre, le rendement a été plus élevé lorsque le buttage avait lieu à la floraison. L'usage d'un herbicide est toutefois nécessaire dans ce dernier cas. Le semis à plat suivi d'un buttage à la floraison a donné une maturité plus hâtive et un poids spécifique plus élevé des tubercules.

Variétés. Les cultivars hâtifs Norland, F61025 et F66095 ont été très productifs en sol minéral tandis que F59095 excellait en sol organique. Pungo a été faible partout. Le cultivar tardif Kennebec excellait par son rendement, suivi de F67070. Hudson a été moins prometteur qu'en 1972. Les cultivars G6880-I et F61025 offrent des possibilités pour les croustilles. La rhizoctonie a affecté la qualité et le rendement.

Flétrissure bactérienne. Les solanacées *Solanum infundibuliforme* Phil. 2948, *S. stoloniferum* Schlecht. 195166 et *S. tuberosum* subsp. *andigenum* (Juz. & Buk.) Hawkes Oka 3937, ainsi que les cultivars 1506B (9), 2070 (30) A et 2070 (54), sont apparus résistants à la flétrissure après inoculation des racines. Les cultivars F70087 et F70108 étaient exempts de symptômes après inoculation avec couteau contaminé. La désinfection du couteau contaminé a été efficace au moyen de trempage durant 1 minute dans une solution de Hyamine 2389 (500 ppm), de Kem-Klean (6 ppm) et de Dex-deorisant (10 ppm) (Kem-San Products Ltd.).

Les fruits

Fraisiers. En deuxième année de production, le rendement équivalait au double de celui de la première année. Les cultivars Guardsman, Redcoat, Sparkle et Veestar ont été les plus productifs. La fraisière était exempte de pétale vert.

Pommiers. Le taux de reprise de la greffe en tête, pratiquée sur *Malus robusta* 5, n'a été que de 2%. Le cultivar Quinte était exempt de rouille.

Pruniers. Les cultivars Bradshaw et Reine-Claude ont produit respectivement 71 et 45 kg par arbre.

Poiriers. Les cultivars Bartlett, Phileson, Clapp Favorite et Miney ont donné un

rendement moyen respectif de 34, 19, 14 et 5 kg par arbre.

FERME EXPÉRIMENTALE NORMANDIN

Les plantes fourragères

Régie du mil. Les variétés Champ et Drummond ont été soumises à différents régimes de fumure et d'exploitation pendant trois années. La production d'herbage a augmenté régulièrement avec des taux de fumure allant jusqu'à 112 kg de N/ha (100 lb/ac). Les apports fractionnés de 34-0-0 ont contribué à l'obtention de rendements moyens atteignant 5 960 kg de matière sèche/ha, comparativement à 5 431 kg/ha avec une dose unique de 33-0-0 au printemps et de 4 920 kg/ha avec une fumure automnale à base d'urée. Cependant, c'est avec les plus hauts taux que les écarts de rendement, résultant des époques où l'azote a été apportée, ont été les plus marqués. Le mil, récolté au début de l'épiaison ou au début de la floraison, a donné des résultats presque identiques, en dépit du fait que le peuplement et la hauteur des plants aient été plus élevés au dernier stade. Les deux variétés de mil ont produit la même quantité de matière sèche et se sont comportées de façon similaire sous les différents régimes d'exploitation.

Régie de mélanges à foin. Les résultats de deux semis identiques exploités respectivement durant trois et quatre années ont démontré que les mélanges mil-luzerne et brome-luzerne sont supérieurs en productivité aux mélanges plus complexes. L'association mil-luzerne a cependant produit un peu plus que celle du brome et de la luzerne, car le brome semble manquer la persistance du mil Champ qui a produit, après quatre années, plus que la luzerne Saranac. De plus, l'analyse botanique a révélé que les légumineuses, particulièrement le trèfle rouge, produisent moins lorsqu'elles sont associées au brome. L'addition de trèfle rouge au mélange mil-luzerne n'a apporté aucun avantage.

Parmi les espèces en culture pure, le brome et la luzerne ont fourni les meilleurs rendements, ceux-ci étant même supérieurs à ceux de certains mélanges. La production du mil a

cependant été réduite par suite d'une défoliation intense résultant de l'attaque de l'hespérie européenne. En général, les mélanges fourragers ont produit au moins 2,2 t de matière sèche/ha (1,0 tonnes/ac) de plus que les espèces semées seules. La culture pure d'espèces, telles que la luzerne, pourrait cependant être avantageuse dans un semis sans plante-abri et désherbé chimiquement.

Dans un autre essai comportant des fauches hebdomadaires d'un mélange de mil, de luzerne et de trèfle rouge, l'analyse botanique du matériel récolté a démontré que la pointe de production des légumineuses se situe à la mi-juillet, alors que la contribution au rendement du mil est au maximum deux semaines plus tard.

Récolte et conservation. Un mélange de mil, de luzerne et de trèfle rouge a été récolté durant quatre années comme ensilage préfané ou comme foin crêpé ou non crêpé, séché dans le champ ou à l'air chaud. Il ressort de cette étude que le crêpage n'a pas réduit le temps de séchage et n'a pas produit un foin de meilleure qualité. L'ensilage et le foin séché à l'air chaud ont donné un fourrage de qualité supérieure. Même si le fourrage coupé à un stade de croissance hâtif a perdu plus de qualité durant la fénaison et l'entreposage, sa valeur alimentaire a été meilleure que celle du fourrage récolté tardivement. L'évaluation de la qualité alimentaire du fourrage par des agneaux a révélé que les gains de poids étaient les mêmes à toutes les méthodes de conservation. La consommation d'un fourrage récolté en l'absence de pluie a été la plus élevée.

Productivité de certaines espèces. Après cinq années d'essai, la variété de luzerne Iroquois a montré une bonne persistance et a produit plus de matière sèche que l'autre variété recommandée, Vernal.

Itasca, une nouvelle variété de mil recommandée, s'est mieux comportée, sur une

période de quatre années, que les variétés Climax et Bounty.

Les céréales

Séchage et entreposage de l'avoine. On a comparé les variations de température et d'humidité du grain d'avoine entreposé, soit en couches minces de 45 à 50 cm d'épaisseur, soit ventilé. A l'entreposage, la teneur moyenne en humidité du grain était de 17,1%. La température du grain est passée à 4,5°C (40°F) en moins de quatre semaines dans l'entrepôt ventilé, comparativement à 12 semaines pour l'entrepôt en couches minces. La diminution de la teneur en eau n'a pas varié significativement entre les méthodes, bien qu'elle ait été un peu supérieure avec la ventilation.

Dates de semis et rendement. Le rendement moyen de neuf variétés d'avoine s'est accru de 21,8% dans le semis du 15 mai, comparativement à un semis effectué deux semaines plus tard. Chez l'orge, l'écart a été encore plus prononcé, soit 35,7% d'augmentation du rendement en faveur du semis fait à la mi-mai. Par contre, neuf variétés de blé ont réagi à l'opposé des deux autres céréales, accusant un rendement supérieur de 17,7% dans le semis du 30 mai.

Les petits fruits et légumes

Régie d'une fraisière. Les résultats d'une année de récolte semblent indiquer que les variétés répondent différemment aux façons culturales. En effet, trois variétés ont été comparées dans une plantation sur billon et dans une autre plantation à plat ou conventionnelle. La variété de mi-saison Redcoat a produit significativement plus de fruits dans le semis à plat, comparativement à la Guardsman, variété tardive, qui semble être favorisée par la méthode sur billon pour la production totale, mais par la méthode conventionnelle pour une récolte hâtive. La variété Veestar a presque doublé le rendement des deux précédentes dans la méthode à plat et cette production a été au maximum dans les premiers dix jours de récolte.

PUBLICATIONS

Recherches

- Barnett, C. M. 1969. Rates and methods of phosphorus placement for corn (*Zea mays* L.). Thèse de M.Sc., Université McGill, Qué.
- Belzile, L. 1972. Effet du chlorure de (2-chloroethyl)triméthylammonium sur la résistance au froid de l'orge d'hiver (*Hordeum vulgare*, var. Dover) et son comportement dans la partie méristématique des feuilles. Thèse de M.Sc., Université Laval, Qué. 70 pp.
- Belzile, L., Paquin, R. et Therrien, H. P. 1973. Effets du chlorure de (2-chloroethyl)triméthylammonium sur le développement et la résistance au gel de l'orge d'hiver Dover. Can. J. Plant Sci. 53:31-36.
- Belzile, L., Paquin, R. et Willemot, C. 1972. Absorption, translocation et métabolisme du chlorure de (2-chloroethyl)triméthylammonium-1,2, ^{14}C chez l'orge d'hiver (*Hordeum vulgare*). Can. J. Bot. 50:2665-2672.
- Bolduc, R. 1973. Déformations ultrastructurales chez les membranes du chloroplaste causées par le froid chez le blé d'hiver. Plant Physiol. 51:27.
- Boucher, Y., Paquin, R., Willemot, C. et Lachance, R. A. 1973. Métabolisme de l'asparagenase et de l'acide aspartique chez *Corynebacterium sepedonicum* (Spieck. et Kott.) Skapt. et Burkh. Can. J. Microbiol. 19:603-607.
- Chiyskowski, L. N., Colpitts, S. R., Coulombe, L. J., Delbridge, R. W., Gourley, C. O., Lawrence, C. H., Murray, R. A., Santerre, J. et Thompson, L. S. 1973. Strawberry green petal disease in Quebec and the Maritime Provinces, 1971-72. Can. Plant Dis. Surv. 53:63-66.
- Comeau, A. et Roelofs, W. L. 1973. Sex attraction specificity in the Tortricidae. Entomol. Exp. & Appl. 16:191-200.
- De Kimpe, C. R., Tabi, M. et Zizka, J. 1973. Influence of basic material on soil genesis in the Thetford - Black Lake area, Province of Quebec. Can. J. Soil Sci. 53:27-35.
- De Kimpe, C. R. et Zizka, J. 1973. Weathering and clay formation in a dunite deposit at Asbestos. Can. J. Earth Sci. 10:1533-1540.
- Deschênes, J. M. 1969. Life-form spectra of contrasting slopes of the grazed pastures of Northern New Jersey. Nat. Can. (Qué.) 96:965-978.
- Drapeau, R. 1973. L'influence de rhizobium envers les champignons pathogènes des légumineuses. Thèse de M.Sc., Université Laval, Qué.
- Drapeau, R., Fortin, J. A. et Gagnon, C. 1973. Antifungal activity of *Rhizobium*. Can. J. Bot. 51:681-682.
- Grenier, G., Mazliak, P., Trémolières, A. et Willemot, C. 1973. Influence du froid sur la synthèse des acides gras dans les racines de deux variétés de luzerne, l'une très résistante et l'autre moins résistante au froid. Physiol. Vég. 11:253-265.
- Hope, H. J. 1973. Protein synthesis during frost hardening of winter wheat. Plant Physiol. 51:26.
- Laflamme, G., Baril, R. et De Kimpe, C. 1973. Caractérisation d'un podzol humo-ferrique, luvisolique et lithique à Esprit-Saint, comté de Rimouski, Québec. Can. J. Soil Sci. 53:145-154.
- Laverdière, M. R. et Cescas, M. P. 1973. Some characteristics of La Pocatière and St-Pascal soils developed on marine sediments in Quebec. Can. J. Soil Sci. 53:155-162.
- Laverdière, M. R. et Laflamme, G. Y. 1973. Quelques propriétés physiques, chimiques et minéralogiques des séries de sol Chaloupe et Batiscan, reliées à leur évolution pédogénétique. Nat. Can. (Qué.) 100:407-420.
- Lister, E. E., Fisher, L. J., Jordan, W. A., Wauthy, J. M., Comeau, J. E. et Proulx, J. 1973. Influence of shelter, level of feeding, and method of forage conservation on packed cell volume and plasma metabolite levels in pregnant beef cows. Can. J. Anim. Sci. 53:81-88.
- Ouellette, G. B. et Pelletier, G. J. 1973. Un autre cas de développement protoplasmique d'un pathogène de flétrissure, le *Verticillium dahliae*. Phytoprotection 54:91.
- Paquin, R. 1973. Effet de quelques acides organiques sur la croissance de *Corynebacterium sepedonicum* en présence de l'asparagine et de la glutamine. Rev. Can. Biol. 32:143-147.
- Paquin, R., Boucher, Y. et Lachance, R. A. 1973. Rôle des acides aminés soufrés dans la croissance de *Corynebacterium sepedonicum* (Spieck. et Kott.) Skapt. et Burkh. Can. J. Microbiol. 19:369-373.
- Pelletier, G. 1973. Influence de certaines méthodes de fenaïson et de conservation sur la qualité d'un mélange fourrager. Nat. Can. (Qué.) 100:385-393.
- Pelletier, G. J., Santerre, J. et Leblond, D. 1973. Les maladies des céréales au Québec en 1972. Phytoprotection 54:91.

- Rioux, R. 1973. Factors influencing glyphosate activity of quackgrass. Thèse de M.Sc., Université de Guelph, Ontario. 73 pp.
- St-Pierre, C. A. 1966. Early generation selection under different environments as it influences agronomic characters of barley. Thèse de M.Sc., Université McGill, Qué. 106 pp.
- St-Pierre, C. A. 1968. Une poulic variable pour régler la longueur des semis des parcelles de céréales. Can. J. Plant Sci. 48:224-226.
- St-Pierre, C. A., Klinck, H. R. et Gauthier, F. M. 1967. Early generation selection under different environments as it influences adaptation of barley. Can. J. Plant Sci. 47:507-517.
- St-Pierre, C. A. et Jensen, N. F. 1972. Evaluating the selection potential of crosses of barley. Can. J. Plant Sci. 52:1029-1035.
- St-Pierre, C. A. et Trudel, M. J. 1972. Effects of ethrel on 14 spring wheat varieties. Agron. Abstr. 28.
- St-Pierre, J. C. et Gervais, P. 1972. Influence des coupes différentielles sur les réserves nutritives de la luzerne. Nat. Can. (Qué.) 99:89-101.
- St-Pierre, J. C. et Trudel, M. J. 1973. Influence de l'acide 2-chloroéthylphosphonique sur la croissance de la fléole des prés. Can. J. Plant Sci. 53:791-796.
- St-Pierre, J. C. et Wright, M. J. 1972. Distribution of ^{14}C -photosynthates in timothy (*Phleum pratense* L.) during the vegetative stage of growth. Crop Sci. 12:191-194.
- Willemot, C. et Verret, G. 1973. Incorporation of choline-1,2- ^{14}C into different molecular species of phosphatidylcholine by alfalfa leaflet tissue. Lipids 8:588-591.
- Divers**
- Bandeen, J. D. et Rioux, R. 1973. Quackgrass control in winter wheat. Res. Rep. Can. Weed Comm. (East. Sect.) p. 290.
- Bandeen, J. D. et Rioux, R. 1973. Fall plowing prior to glyphosate application for quackgrass control. Res. Rep. Can. Weed Comm. (East. Sect.) pp. 290-291.
- Bandeen, J. D. et Rioux, R. 1973. Fall versus spring application of glyphosate for quackgrass control. Res. Rep. Can. Weed Comm. (East. Sect.) p. 291.
- Bandeen, J. D. et Rioux, R. 1973. Fall application of glyphosate for quackgrass control. Res. Rep. Can. Weed Comm. (East. Sect.) pp. 291-292.
- Barnett, G. M. et Bullen, M. R. 1972. Controlled water tables and crop yields. Soil Horiz. 13(3):13-16.
- Barnett, G. M. et Comeau, A. 1973. Fertility disease relationships. Soil Horiz. 14(1):11-14.
- Barnett, G. M. et Mackenzie, A. F. 1972. Phosphorus efficiency for corn in Québec. Soil Horiz. 13(3):17-19.
- Barnett, G. M. et Mackenzie, A. F. 1973. Phosphorus placement and corn grain in marginal areas. Soil Horiz. 14(1):15-18.
- Belzile, L. et Rioux, R. 1973. Quand faut-il semer la luzerne? Can. Agric. 18(2):21-22.
- Belzile, L. et Rioux, R. 1973. La meilleure date pour semer la luzerne. Actual. Agric. 33(6):16-17.
- Bullen, M. R. 1973. Timothy Plus newsletter. Forage Notes 18:14-15.
- Bullen, M. R. et Venne, P. R. 1973. A computer memory for *Phleum* literature. Timothy Plus 1:6.
- Comeau, A. et Barnett, G. M. 1973. Varietal susceptibility to BYDV. Soil Horiz. 14(1):15.
- Comeau, J. E. et Barnett, G. M. 1973. Semez tôt pour avoir les minots. Actual. Agric. 33(5):18-22.
- Dubuc, J. P. (ed.). 1973. Rapport sur le projet d'amélioration de l'avoine. Groupe du Québec.
- Dupuis, G., Darisse, F. et Leduc, C. 1973. Séchage du foin dans le champ en piles pyramidales de six balles. Bull. Tech. 21:1-30. Min. Agric., Qué.
- Gagnon, C. 1973. Recherches sur les maladies des plantes fourragères au Québec. Agriculture 30:4-10.
- Généreux, H. 1972. Résistance des semis et variétés de pommes de terre à la flétrissure bactérienne. Can. Hort. Counc. p. 19.
- Généreux, H. 1972. Potato seed treatment. Can. Hort. Counc. p. 20.
- Généreux, H. 1972. Disinfection of knives and wooden boxes. Pestic. Res. Rep. p. 274.
- Généreux, H. (ed.). 1972. Rapport annuel des essais régionaux de pommes de terre au Québec. p. 92.
- Godbout, E. 1971. Le rutabaga. Minist. Agric. Can. Publ. 1430. 39 pp.
- Martel, Y. 1973. Pourquoi utiliser des engrais chimiques? Actual. Agric. 33(3):16-18.
- Martel, Y. et De Kimpe, C. 1973. Votre sol est-il trop acide? Actual. Agric. 33(3):19-21.
- Pelletier, G. J. et Couture, L. 1973. Rapport d'enquête pathologique—Parcelles d'essai de variétés de céréales au Québec. C.P.V.Q. 21 p.

- Pelletier, G. et Grenier, G. 1973. Séchage et entreposage des petites récoltes d'avoine. Agdex 113.6.
- Rioux, R. 1973. Effet à long terme de la pronamide sur la luzerne et le chiendent. Res. Rep. Can. Weed Comm. (East. Sect.) p. 106.
- Rioux, R., Comeau, J. E. et Généreux, H. 1972. Contrôle des mauvaises herbes et méthodes de culture des pommes de terre. Can. Hort. Counc. p. 19.
- St-Pierre, C. A. (ed.). 1973. Rapport sur l'amélioration de l'orge. Groupe du Québec. N° 16. 41
- St-Pierre, C. A. et St-Pierre, J. C. 1972. Une grosse récolte commence par des semences certifiées. Actual. Agric. 33:26-28.
- St-Pierre, J. C. 1973. Augmentez la valeur de vos fourrages. Actual. Agric. 33(6):18-29.
- Turnbull, J. C. et Darisse, J. P. F. 1973. Ventilation of dairy barns with porous ceiling inlet systems: part 2. Pap. N° 73-216. Can. Soc. Agric. Eng. Annu. Meet., Victoria, B.C.

Station de recherches Saint-Jean, Québec

CADRES PROFESSIONNELS

J. J. JASMIN, B.Sc. (Agr.), M.Sc.
Y. BONNEAU

Directeur
Services administratifs

Cultures fruitières

R. O. PARADIS, B.A., B.Sc. (Agr.), M.Sc., Ph.D.

Chef de la section; écologie de la
faune entomologique

A. BÉLANGER, B.Sc., Ph.D.

Chimie des pesticides

L. J. COULOMBE, B.A., B.Sc. (Agr.), M.Sc., Ph.D.

Phytopathologie

R. L. GRANGER, B.A., B.S.A., M.Sc.

Physiologie

M. LAREAU, B.Sc. (Agr.)

Régie des cultures

B. PARENT, B.A., B.Sc. (Agr.), M.Sc.

Écologie et répression des acariens
et des homoptères

I. RIVARD, B.A., B.Sc. (Agr.), M.Sc.

Écologie et répression des insectes

G. L. ROUSSELLE¹, B.A., B.Sc. (Agr.), M.Sc.

Génétique

Cultures maraîchères

E. J. HOGUE, B.A., B.S.A., M.Sc., Ph.D.

Chef de la section; physiologie et
malherbologie

R. BERNIER B.A., B.Sc. (Agr.)

Régie des cultures

M. S. CHIANG, B.Sc. (Agr.), M.Sc., Ph.D.

Génétique

R. CRÊTE, L.S.A., M.Sc.

Phytopathologie

H. A. HAMILTON, B.Sc. (Agr.), M.Sc., Ph.D.

Chimie des sols organiques

M. HUDON, B.S.A., M.Sc.

Écologie et répression des insectes
du maïs

K. A. MACMILLAN, B.Sc. (Agr.), M.Sc., Ph.D.

Nutrition des plantes

P. MARTEL, B.A., B.Sc., Ph.D.

Toxicologie

T. C. VRAIN², M.B.V., D.E.A.

Nématologie

Départ

P. RICARD, B.Sc., M.Sc.

Chimie des pesticides

Démission, janvier 1973

SCIENTIFIQUE EN SÉJOUR D'ÉTUDE

J. FOREST, B.S.A.
Étudiante post-gradué

Entomologie

DIVISION DE LA DÉFENSE DES CULTURES

Ministère de l'Agriculture du Québec

M. MAILLOUX, B.S.A., M.Sc.

Protection des vergers

¹En congé d'étude à l'Université Rutgers, New Brunswick, N.J.

²En congé d'étude à l'Université North Carolina State, N.C.

INTRODUCTION

Le rapport qui suit donne une idée des travaux les plus significatifs, qui ont été réalisés en 1973, dans les domaines de compétence assignés à la Station de recherches de Saint-Jean, soit les productions fruitières et maraîchères.

Durant l'année, M. Pierre Ricard (chimie des pesticides) nous a quittés et a été remplacé par le Dr André Bélanger. M. Thierry Vrain est également venu rejoindre les rangs de notre équipe de chercheurs.

Nous avons essayé, en 1973, d'évaluer aussi impartialement que possible notre programme de recherches et de l'orienter graduellement vers les problèmes prioritaires de l'industrie horticole du Québec et de l'est du Canada. Il nous a fallu pour cela une étude systématique des principales productions. La productivité de la Station a quelque peu augmenté en 1973 et un effort particulier a été marqué dans le domaine de la publication d'articles de vulgarisation.

On peut obtenir des exemplaires des publications mentionnées à la fin de ce rapport ou des informations additionnelles en adressant sa demande directement aux chercheurs ou à la Station, comme suit: Station de recherches, Agriculture Canada, Casier postal 457, Saint-Jean, Qué. J3B 6Z8.

J. J. Jasmin
Directeur

ARBRES FRUITIERS

Entomologie

Tétranyque rouge du pommier. Nous avons maintenu une parcelle écologique expérimentale exempte d'insecticides, à l'exception d'un traitement à l'arséniate de plomb contre la mouche de la pomme, *Rhagoletis pomonella* (Walsh). Une lutte biologique s'y est exercée contre le tétranyque rouge, *Panonychus ulmi* (Koch), mais non contre l'ériophyide du pommier, *Aculus schlechtendali* (Nal.), sans doute parce que les acariens prédateurs du genre *Typhlodromus* étaient peu nombreux. Quant à la recherche sur la lutte intégrée, le fongicide Dikar (Rohm & Haas Co.) et l'acaricide Acarthane (Rohm & Haas Co.) se sont révélés passablement efficaces contre *P. ulmi* et peu nuisibles aux ennemis naturels. Dans les essais d'acaricides effectués au début de l'été, le produit Carzol (chlorhydrate de formetanate; FMC of Canada Ltd.) s'est révélé très efficace par sa rémanence. D'autres essais d'acaricides effectués en serre ont démontré que les produits Vydate (DuPont of Canada Ltd.) et BTS 27419 (The Boots Co.) étaient très prometteurs contre *P. ulmi*. Des essais de fumigation de pommes pour tuer les oeufs d'hivernement de *P. ulmi* ont démontré que le dibromoéthane au taux de 9,3 mg/litre pendant 4 heures avait produit une mortalité de presque 100% (99,71%).

Cochenille virgule. Dans une recherche sur la lutte biologique, les populations de la cochenille *Lepidosaphes ulmi* (L.) ont diminué sensiblement à la suite de l'augmentation des prédateurs et des parasites, particulièrement de l'acarien *Hemisarcoptes malus* (Shimer) et du chalcide *Aphytis proclia* (Wlk.). Dans une recherche sur la lutte intégrée contre *L. ulmi*, les traitements à l'huile émulsionnable et au leptophos parurent moins nocifs aux ennemis naturels que le phosmet, le fenitrothion et le methidathion.

Charançon de la prune. Dans des essais insecticides contre *Conotrachelus nenuphar* (Hbst.) infestant les pommiers, deux applications des produits methidathion, PP-484 (Chipman Chemicals Ltd.), Torak (Ciba-Geigy Canada Ltd.) et phosalone ont fourni de 97 à 99% de fruits sains, alors que le taux de pommes infestées sur des arbres voisins non traités était de 32%.

Attraction sexuelle. Des phéromones sexuelles de synthèse employées comme méthode de piégeage a permis de capturer 2 073 mâles de la pyrale de la pomme, *Carpocapsa pomonella* (L.), 936 de la tordeuse à bandes rouges, *Argyrotaenia velutinana* (Wlk.) et 284 de la tordeuse à bandes obliques, *Choristoneura rosaceana* (Harr.). Dans chacun des vergers inventoriés, les dégâts ont été systématiquement évalués afin de déterminer les

densités critiques nécessitant l'emploi de traitements insecticides.

Mouche de la pomme. L'émergence des adultes de *R. pomonella* a débuté une semaine plus tôt mais a semblé moins abondante qu'en 1972. En raison probablement de la faible infestation naturelle qui en est résultée, quatre pulvérisations d'une vingtaine de produits insecticides mis à l'essai et appliqués aux moments les plus opportuns, soit à intervalles de 10 à 12 jours à partir du début de juillet, ont pu fournir une récolte de fruits pratiquement sains à 100%.

Phytopathologie

Tavelure du pommier. Une seule application de captafol à dose massive (5,7 litres/450 litres ou 45 litres/ha) a été effectuée sur des pommiers McIntosh adultes à la fin d'avril, soit au stade du débourrement avancé. Environ un mois après ce traitement, il y a eu cinq applications de dodine à dose normale du 31 mai au 28 juin. Une répression adéquate de la tavelure du pommier, *Venturia inaequalis* (Cke.) Wint., a été obtenue, ce qui corrobore les résultats obtenus au cours des trois années précédentes.

Dans des essais de traitements réguliers contre la tavelure sur des pommiers McIntosh, 13 applications des fongicides dodine, benomyle, Dikar, thiophanate de méthyle et UniRoyal 2013 (UniRoyal Chemical Ltd.), employés aux doses recommandées par les fabricants, ont donné un taux de répression de la tavelure de 98% et plus malgré des conditions très favorables au développement de l'organisme.

Génétique

Introduction d'un nouveau cultivar de pommes. A l'automne 1973, la sélection de pomme mi-saison O-294 fut nommée Blair. Le nouveau cultivar, du type McIntosh, mûrit 10 jours avant celle-ci.

Introduction d'un nouveau clone porte-greffe de pommier. Le nouveau clone porte-greffe de pommier Ottawa-3, à la fois nainisant, rustique et favorisant la précocité du scion, gardera son nom et sera distribué aux pépiniéristes au printemps 1974. Ottawa-3 s'est avéré, selon nos essais, difficile à multiplier en cépée, mais relativement facile à multiplier par boutures de bois non aoûté ou par boutures de racines.

Cultivars de pommes à cidre. Nous possédons maintenant trois lignées d'un cultivar utile à la fabrication du cidre en raison de sa riche teneur en anthocyanine et en tanin, ainsi que de sa forte résistance à la tavelure. Nous avons introduit, en outre, 15 cultivars de pommes à cidre en provenance de Suisse et d'Angleterre.

Cultivars de Cortland à lambourdes. Nous avons obtenu du Danemark, le 24 janvier 1973, trois lignées de mutants artificiels du cultivar Cortland que nous avons multipliées pour fin expérimentale seulement.

Développement de cultivars de pommiers résistants à la tavelure. La saison de pollinisation artificielle 1973 a été difficile à cause des conditions climatiques et seulement 11 des 21 croisements contrôlés effectués ont produit quelques fruits hybrides.

Plus de 1 800 semis résistants à la tavelure se sont ajoutés en pépinière aux quelque 6 000 déjà établis depuis le printemps 1972. Tous ces semis ont été inoculés en serre avec des cultures de *V. inaequalis* et se sont montrés résistants. Quelque 5 000 semis résistants à la tavelure sont déjà établis dans un verger à haute densité sur leurs propres racines pour l'évaluation des fruits.

Des scions de O-531, O-532 et O-533 sont disponibles en quantité limitée pour ceux qui voudraient faire l'essai de ces trois sélections résistances à la tavelure.

Évaluation de cultivars de prunes et de poires. L'évaluation des cultivars s'est poursuivie en collaboration avec la Station de recherches de Ste-Foy, à leur ferme satellite de La Pocatière. Le cultivar de prunier Bradshaw donna en 1973, à l'âge de 13 ans, le meilleur rendement moyen par arbre, soit 71,2 kg. Les autres pruniers âgés de 13 ou de 29 ans rapportèrent de 19 à 45 kg en moyenne.

Bartlett, le meilleur cultivar de poirier, rapporta, en 1973, 284 kg de fruits en moyenne, à l'âge de 55 ans. Les autres cultivars âgés de 30 ou de 52 ans rapportèrent entre 102 et 159 kg de fruits en moyenne.

Régie des pommeraies

Évaluation des atomiseurs à pulvérisation concentrée. Des essais de pulvérisations concentrées avec quatre atomiseurs à prise de

pouvoir au tracteur (P.T.O.) ont été poursuivis en 1973. L'emploi de teinture phosphorescente ainsi que des comptages sur le pourcentage d'infection à la tavelure nous indiquent l'efficacité de chaque machine à distribuer le produit d'arrosage dans toutes les parties des arbres. Les résultats obtenus à date nous indiquent qu'il est possible d'utiliser efficacement ces pulvérisateurs même dans des vergers plantés avec des pommiers standards.

PETITS FRUITS

Entomologie

Écologie. L'étude de la faune des fraisières et des framboisières nous a fait découvrir une foule d'insectes nuisibles ou utiles, en tout quelque 70 espèces différentes parmi lesquelles les espèces nuisibles suivantes qui se trouvaient dans les deux cultures: la chrysomèle rhizophage du fraisier, *Paria fragariae* Wilcox, la cicadelle de la pomme de terre, *Empoasca fabae* (Harr.), la punaise terne, *Lygus lineolaris* (P. de B.), et plusieurs autres sur l'une ou l'autre culture. Il est à noter que le tétranyque rouge, *Panonychus ulmi* (Koch), infestait les framboisiers en aussi grand nombre que le tétranyque à deux points, *Tetranychus urticae* Koch.

Phytopathologie

Blanc du fraisier. Les essais de fongicides visant à enrayer le blanc du fraisier, *Sphaerotheca humuli* (DC.) Burr., ont été continués afin d'augmenter les rendements chez les cultivars Earlidawn, Grenadier, Cavalier et Redcoat. Quatre applications des produits dinocap, thiophanate de méthyle et Kolospray (FMC of Canada Ltd.) ont été effectuées du 19 juillet au 29 août 1972 sur les plantations de première année. D'après les résultats obtenus en 1973, aucun de ces fongicides n'a contribué à une augmentation significative des rendements chez tous les cultivars.

Génétique

Évaluation de cultivars et sélections de fraisiers. Depuis ces dernières années, nous avons évalué entre 8 à 20 cultivars de fraisiers à L'Acadie et La Pocatière. A date, au moins trois cultivars se sont montrés très prometteurs aux deux endroits. Le cultivar Bounty dont les rendements varièrent entre

15 à 18 t/ha s'est montré souvent supérieur au Redcoat quant à son rendement, à son époque de cueillette et à la qualité de son fruit à l'état frais et pour la transformation. Les cultivars Veestar et Vibrant, quoique moins productifs, sont également prometteurs en raison de leur époque de cueillette et de la qualité de leur fruit à l'état frais et pour la transformation.

Régie des cultures

Nouvelle méthode de culture du framboisier. Des tiges complètes de deux cultivars de framboisier, Willamette et Latham, ont été arrachées à l'automne et mises en caveau. Ces tiges, plantées au printemps de 1973, ont produit la même année et des rendements allant jusqu'à 355,86 g de fruits par tige ont été obtenus avec l'une des 27 différentes applications d'engrais chimique.

MAÏS

Génétique

Résistance à la pyrale du maïs. Dans le cadre d'une coopération internationale en vue de l'amélioration du maïs pour la résistance à la pyrale, quatre lignées canadiennes (CO114, 221, 103 et 106) furent mises à l'essai dans 12 pays. A Saint-Jean, sauf CO114, elles ont semblé résistantes à la pyrale. Certaines lignées provenant de l'Autriche (NR1240), des E.-U. (A619) et de la Roumanie (T146, T341) furent très résistantes à la pyrale pour ce qui est de la criblure du feuillage. Quatre hybrides simples d'URSS ont démontré une certaine résistance, tandis que six hybrides simples de Yougoslavie furent classés intermédiaires.

L'hérédité de la résistance aux attaques sur feuilles par la pyrale du maïs grain a été étudiée par un essai de croisements en diallèles 6×6 . Les résultats indiquent, comme le test 8×8 de l'année dernière, que l'action additive des gènes fut la plus importante; cependant, la variation provenant des effets de dominance des gènes (H_1) fut statistiquement significative au niveau de 5%. L'hérédité de ce caractère est estimée à 43%.

CAROTTE ET MINI-CAROTTE

Entomologie

Charançon de la carotte. L'enquête menée en 1973 chez les producteurs indique que l'insecte a agrandi son aire de distribution. L'infestation se répartit dans les 15 premiers rangs du champ. Les adultes redeviennent actifs au printemps lorsque la température du sol s'élève au-dessus de 4,4°C. Les résultats de la lutte chimique obtenus en 1973 démontrent la possibilité de répression avec les insecticides à courte rémanence.

Malherbologie

Nouvelles mauvaises herbes. Plus de 75% de l'étendue de carottes en sol organique du sud-ouest du Québec est envahie par une nouvelle plante adventice. Le bident penché, *Bidens cernua* L., s'est répandu rapidement dans cette culture et est un problème sérieux sur quelques centaines d'hectares, grâce sans doute à des pratiques culturales et à des conditions climatiques particulières. Les producteurs qui ont un problème sérieux avec cette plante ne pratiquent pas de rotations et emploient les herbicides seulement en post-émergence. De plus, cette mauvaise herbe semble être particulièrement adaptée à des conditions de sol humide, conditions qui ont prévalu durant les dernières deux saisons de végétation dans les sols organiques du Québec.

Fertilisation et nutrition

Engrais potassique. Une augmentation dans la dose d'application de la potasse se traduit par une augmentation dans le rendement de la carotte, indépendamment de la présence ou de l'absence d'azote ou de phosphore. En présence de N et de P, le rendement optimum apparaît au taux de 179,2 kg/ha de K alors qu'en absence de N et de P, le rendement optimum apparaît à des doses plus élevées de K. Le pourcentage de racines vendables est plus élevé lorsque N et P sont appliqués avec le potassium (50,3 à 61,5% vendable) que lorsque N et P ne sont pas appliqués (40,3 à 52,4% vendable).

Nouvelle culture

La mini-carotte. Une étude préliminaire en parcelle sur la mini-carotte fut entreprise au cours de l'été 1973 à la suite de quelques essais en serre. Une dizaine de variétés d'origines européenne et américaine furent

semées à l'aide d'un semoir Planet Jr N° 7 pour en évaluer le rendement, la forme extérieure, le diamètre au collet et la longueur et le pourcentage vendable en cello.

Le rendement moyen total et vendable, respectivement de 12,61 et 4,98 t/ha, est au moins 50% sous la normale. La longueur et le diamètre au collet furent en moyenne de 108,6 mm et 19,7 mm. Le pourcentage moyen de racines vendables s'est chiffré à 39,1% et a varié de 3,8% pour la variété Chantenay 6028 à 50,3% pour la variété Amstel.

La hauteur moyenne du feuillage à la récolte est de 27 mm et varie de 18 mm pour la variété Baby Finger (Stokes) à 35 mm pour Chantenay 6028 (Hollande). Le court feuillage de Baby Finger peut devenir un problème lors de la récolte mécanique, surtout après les gelées du début d'octobre.

Le rendement médiocre est dû aux conditions climatiques adverses, pluies abondantes et manque de drainage. Cinq variétés furent retenues pour une étude ultérieure plus poussée, dont les variétés Amstel et Baby Finger qui sont actuellement cultivées de façon commerciale.

OIGNON

Phytopathologie

Épidémiologie et répression du charbon. Des dix préparations fongicides utilisées en traitements de semences contre le charbon, aucune n'a surclassé le Pro-Gro 80D (UniRoyal Chemical Ltd.), à 25 g/kg, avec seulement 2,6% de charbon. Cinq autres traitements ont donné aussi d'excellents résultats, avec 3 à 6% de charbon. Quatre des cinq meilleurs traitements contre le charbon, incluant le Pro-Gro à demi-dose, ont aussi donné les rendements les plus élevés, 25 à 27 t/ha comparativement à 10 à 13 t/ha pour le Derosal (HOE 174110F; Hoechst Chemicals), le quintozone et le témoin. Une épreuve de résistance au charbon a démontré la susceptibilité de 16 variétés d'oignons. Les variétés Buccaneer, Mustang et Northern Oak avaient de 15 à 20% de charbon tandis que les 13 autres avaient jusqu'à 55% de charbon.

CHOU

Génétique

Une épreuve de résistance à la hernie des crucifères, races 2 et 6, comprenant plusieurs lignées et introductions de chou et de navette (*Brassica napus* L.) a été réalisée en 1973. Seules la lignée de chou F₇ (24-127 × 8-41) et la navette cv. Nevin ont montré de la résistance.

Des croisements entre le rutabaga cv. Wilhelmsberger et le chou cv. Badger Shipper furent réalisés en vue de transférer au chou le gène (ou les gènes) de résistance appartenant au Wilhelmsberger.

Le pollen de chou peut être entreposé à 4°C pour une période de 25 jours sans perte de viabilité; par contre, le pollen ne survit pas à la congélation.

TOMATE

Régie des cultures

On a démontré qu'en utilisant une variété de tomate hâtive, des techniques très précises de production de plants et une régie spécifique en champs, on pouvait obtenir des rendements de primeurs très élevés. Les facteurs les plus importants, d'après nos essais, sont d'abord une variété hâtive telle la New Yorker; ensuite, dans la production du plant, on doit éviter de soumettre les plantules au stress tel que causé par le dessèchement du sol, la température très élevée du jour ou de la nuit, un niveau de fertilité trop bas et la présence d'insectes. La transplantation faite au moment voulu est critique dans le cas des variétés à croissance déterminée. L'emploi du régulateur de croissance Ethrel (Amchem Products Inc.), au stade des trois vraies feuilles, suivi d'une autre application dans le champ lorsque 5% des fruits sont frappés, est le facteur qui a contribué le plus à produire un rendement élevé de primeurs (cueillis avant le 1^{er} août), soit 20 000 kg/ha. L'emploi de paillis de plastique clair a aussi contribué à ce haut rendement.

DIVERS

Nutrition des plantes

La transformation des formes azotées en sol organique. L'application en laboratoire de différents sels d'ammonium, soit NH₄Cl, NH₄NO₃, (NH₄)₂SO₄ et NH₄HPO₄, à un sol organique a influencé, de façon négligeable, la transformation des formes azotées. Le chaulage, cependant, au taux de 9 t/ha fait passer le pH de 3,8 à 4,3 après 24 semaines d'incubation. Ceci produit une accumulation d'azote sous forme de NO₃⁻ et non de NH₄⁺ comme il existe sous des conditions plus acides. L'échantillonnage de différents niveaux de sols démontre que la transformation de l'azote organique en azote sous forme de NO₃⁻ ou de NH₄⁺ diminue avec la profondeur de l'échantillon.

Variations saisonnières dans la transformation des formes azotées. Des sols organiques, supportant diverses cultures et soumis à différents régimes de fertilisation, ont été échantillonnés de mai à novembre à cinq niveaux de profondeur, 0 à 20, 20 à 40, 40 à 60, 60 à 80 et 80 à 100 cm, pour y déterminer l'azote présent sous forme de NH₄⁺ et NO₃⁻. L'application de K, à différentes doses, a apporté peu de variation dans les concentrations de NO₃⁻ et NH₄⁺ au cours de la saison. Dans un champ où il y a eu production de carottes, céleri, oignons et laitue de façon continue sur une période de huit années sans addition de fertilisants, on n'a observé aucune influence de la récolte sur les concentrations de NH₄⁺ mais un effet prononcé sur les concentrations de NO₃. Dans les échantillons provenant des couches de surface, les concentrations de NO₃ au cours de la saison ont été plus élevées dans les parcelles de céleri, suivi en ordre décroissant par les parcelles d'oignons, de carottes et de laitue. Dans tous les traitements, les concentrations de NO₃⁻ ont augmenté jusqu'en août, pour ensuite décroître. Le pH acide du sol n'a pas retardé le taux de formation du NO₃⁻ tel qu'indiqué par l'absence d'accumulation de NH₄⁺.

PUBLICATIONS

Recherches

Basu, P. K., Crête, R., Donaldson, A. G., Gourley, C. O., Haas, J. H., Harper, F. R., Lawrence, C.

H., Seaman, W. L., Toms, H. N. W., Wong, S. I. et Zimmer, R. C. 1973. Prevalence and severity of diseases of processing peas in

- Canada, 1970-71. Can. Plant Dis. Surv. 53:49-57.
- Bédard, P. R., Hsu, C. S., Spangelo, L. P. S., Fejer, S. O. et Rousselle, G. L. 1971. Genetic, phenotypic and environmental correlations among 28 fruit and plant characters in the cultivated strawberry. Can. J. Genet. Cytol. 13:470-479.
- Bénazet, J. et Parent, B. J. 1973. Essais de fumigation de pommes avec le dibromoéthane pour tuer les oeufs d'hivernement de *Panonychus ulmi* (Koch). Phytoprotection 54:96-104.
- Chiang, M. S. et Hudon, M. 1973. Inheritance of resistance to the European corn borer in grain corn. Can. J. Plant Sci. 53:779-782.
- Chiang, M. S. et Nip, W. K. 1973. Free amino acid content in leaf and root tissues of clubroot-resistant and clubroot-susceptible cabbages. Euphytica 22:393-398.
- Chiyskowski, L. N., Colpitts, S. R., Coulombe, L. J., Delbridge, R. W., Gourley, C. O., Lawrence, C. H., Murray, R. A., Santerre, J. et Thompson, L. S. 1973. Strawberry green petal disease in Quebec and Maritime Provinces, 1971-72. Can. Plant Dis. Surv. 53:63-66.
- Coulombe, L. J. 1973. Le faux-gui sur le sapin baumier. Phytoprotection 54:46-47.
- Crête, R. et Tartier, L. 1973. Trois années d'essais de lutte chimique contre le charbon de l'oignon, *Urocystis magica*. Phytoprotection 54:32-42.
- Granger, R. L. 1973. Register of new fruit and nut varieties list 28: Apple, Blair. HortScience 8:378.
- Hamilton, H. A. et Bernier, R. 1973. Effects of lime on some chemical characteristics, nutrient availability, and crop response on a newly broken organic soil. Can. J. Soil Sci. 53:1-8.
- Hudon, M. et Martel, P. 1973. Les insectes des cultures maraîchères dans le sud-ouest du Québec en 1972. Ann. Soc. Entomol. Qué. 18:3-4.
- Martel, P. et Daneau, J. 1973. Evaluation of furrow applied insecticides for the control of the onion maggot, *Hylemya antiqua* (Meig.), in southwestern Quebec. Phytoprotection 54:51-56.
- Parent, B. 1973. Natural population densities of the European red mite on apple in Quebec. Environ. Entomol. 2:1064-1068.
- Parent, B. et Pitre, D. 1973. Sélection de nouveaux acaricides en serre sous des conditions climatiques constantes. Phytoprotection 54:105-119.
- Rivard, I. 1973. Inventaire historique sur les fluctuations de population de la mouche de la pomme, *Rhagoletis pomonella* (Walsh), dans le sud-ouest du Québec. Ann. Soc. Entomol. Qué. 18:126-137.
- Rivard, I., Parent, B., Paradis, R. O. et Mailloux, M. 1973. Les ravageurs des cultures fruitières dans le sud-ouest du Québec en 1972. Ann. Soc. Entomol. Qué. 18:5-6.
- Spangelo, L. P. S., Hsu, C. S., Fejer, S. O., Bédard, P. R. et Rousselle, G. L. 1971. Heritability and genetic variance components for 20 fruit and plant characters in the cultivated strawberry. Can. J. Genet. Cytol. 13:443-456.

Divers

- Chiang, M. S. et Crête, R. 1973. Châteauguay cabbage/Le chou Châteauguay. Canadex 252.33.
- Chong, C. et Lareau, M. 1973. Outlook for a buoyant strawberry industry. Macdonald J. 34:7-9.
- Coulombe, L. J. 1973. Pommes tavelées, prunes coulées et cerises véreuses. Bull. des Agriculteurs, mars, pp. 74-76.
- Coulombe, L. J. 1973. Vos céréales se font manger par les pucerons. Bull. des Agriculteurs, mai, pp. 15, 54-55.
- Hudon, M. 1973. Factors affecting corn borer epidemic, 1973. Canadex 111.622.
- Hudon, M. 1973. Les causes de l'épidémie de la pyrale du maïs en 1973. Actual. Agric. 33:8-9.
- Hudon, M. 1973. La lutte contre la pyrale du maïs conduit M. Marcel Hudon à travers l'Europe centrale. Québec Hortic. 13:20-22.
- Hudon, M. and International Cooperators on *Ostrinia nubilalis* (Hbn.). 1973. International reactions of dent corn inbred lines to European corn borer populations. Canadian vs pooled international data. Rep. Int. Project on *O. nubilalis*. Phase I: Results of 1969-70. Agric. Res. Inst. Hungarian Acad. Sci., Martonvasar, Hungary. pp. 62-86.
- Hudon, M. and International Cooperators on the corn borer. 1973. International reactions of dent corn inbred lines to European corn borer populations. Canadian vs pooled international data. 7th Meet. Eucarpia, Maize and Sorghum Sect., Zagreb, Yugoslavia. Disease and Pests Sect. p. 7.
- Jasmin, J. J. 1973. La protection, un facteur important de l'économie et de l'écologie. Phytoprotection 54:78-82.
- Jasmin, J. J. 1973. La Station de Recherches de, Saint-Jean, Québec. Québec Hortic. 13:12-15.

- Jasmin, J. J. 1973. La production des fruits et des légumes au Québec: situation et avenir. *Actual. Agric.* 33:16-19.
- Lareau, M. et Granger, R. L. 1973. La Spartan, pomme rentable au Québec. *Québec Hortic.* 3:14-16.
- Maltais, J. B. et Paradis, R. O. 1973. Notice nécrologique: Georges Gauthier, 1901-1972. *Ann. Soc. Entomol. Qué.* 18:103-107.
- Martel, P. 1973. Où en sommes-nous avec le charançon de la carotte? *Rev. Annu., Assn. des Jardiniers-Maraîchers de la région de Montréal*, pp. 38-39.
- Paradis, R. O. 1972. Notice biographique: Dr J. L. Auclair, Président, Société entomologique du Québec. *Ann. Soc. Entomol. Qué.* 17:115-116.
- Paradis, R. O. 1973. Quelques notes historiques—Historical highlights. *Ann. Soc. Entomol. Qué.* 18(2), suppl., pp. 4-5. (*Aussi dans Bull. Entomol. Soc. Can.* 5:106.)
- Parent, B. 1971. La Société de Protection des Plantes du Québec. Discours présidentiel, 1971. *Phytoprotection* 52:84-86.
- Voisey, P. W., Buckley, D. J. et Crête, R. 1973. Evaluation of a system for measuring small deformation in the physical testing of food. *Rep. 7221, Eng. Res. Serv.*
- Vrain, T. et Hogue, E. J. 1973. Les pertes causées par les nématodes sur la carotte d'automne. *Rev. Annu., Assn. des Jardiniers-Maraîchers de la région de Montréal*, pp. 66-68.

Research Station Delhi, Ontario

PROFESSIONAL STAFF

L. S. VICKERY, B.S.A., M.S.

Director

Tobacco

H. H. CHENG, B.Sc., M.Sc., Ph.D.

Entomology

W. A. COURT, B.Sc., M.Sc., Ph.D.

Chemistry

J. M. ELLIOT, B.S.A., M.S.A.

Soil science

S. K. GAYED, B.Sc., M.Sc., Ph.D.

Plant pathology

R. S. PANDEYA, B.Sc., M.Sc., Ph.D.

Genetics and plant breeding

N. ROSA, B.Sc., Ph.D.

Plant physiology

E. K. WALKER, B.S.A., M.S.

Plant science

F. H. WHITE, B.Sc., M.Sc.

Genetics and plant breeding

B. F. ZILKEY, B.S.A., M.Sc., Ph.D.

Plant physiology

EXTENSION SERVICES¹

M. C. WATSON, B.S.A.

Tobacco

N. W. SHEIDOW, B.Sc.

Tobacco

¹Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Research Station, Delhi, specializes in tobacco research with emphasis on production and health. Cooperative programs with Health and Welfare Canada, the University of Waterloo, and the University of Kentucky are in progress.

This report contains summaries of major accomplishments during 1973. Detailed information may be obtained from the individual scientists or by writing for any of the publications listed. Correspondence should be addressed to: Research Station, Research Branch, Agriculture Canada, Delhi, Ont. N4B 2W9.

L. S. Vickery
Director

SOIL SCIENCE

Soil Fertility

Nitrogen. In a loamy sand treated with the fumigant nematicide DD, levels of NH_4^+ -N tended to be higher and NO_3^- -N lower throughout June 1971. Seven weeks after fumigation, the level of NH_4^+ -N reached 16 ppm compared with 6 ppm in the control plots; 10 wk after fumigation, all plots decreased to 3 ppm and remained constant until harvest time. The highest levels of NO_3^- -N (about 20 ppm) occurred 9–10 wk after fumigation. In 1972, after treatment with DD, the level of NH_4^+ -N tended to be higher and NO_3^- -N lower throughout the monitoring period; 4 wk after fumigation, NH_4^+ -N reached a peak of 20 ppm compared with 13 ppm in the control treatment. Levels decreased by the 9th wk to 4 and 2 ppm for the DD and control treatments. Ten weeks after fumigation, levels of NO_3^- -N were 29 and 14 ppm for the control and DD treatments, but fell to 12 and 6 ppm 2 days later, after a heavy rainfall. Mocap, a nonfumigant nematicide, had no apparent effect on NH_4^+ -N and no consistent effect on NO_3^- -N in 1971 and 1972. In 1973, Telone and Telone C resulted in higher levels of NH_4^+ -N in the soil from May 17 until July 3, and Vorlex gave higher levels only until June 12. Vydate, a nonfumigant nematicide, had no effect on the levels of NH_4^+ -N. The levels of NO_3^- -N were lower from the 2nd to the 4th wk after application of the fumigants and tended to be lower than in the control plots for another 7 wk.

A comparison of four rates of N, 0, 22.4, 44.8, and 67.2 kg/ha (0, 20, 40, and 60 lb/ac), showed that each increment tended to increase yield, total N, and total alkaloids and to decrease reducing sugars of the cured

leaves. The amount of nicotine in a cigarette increased as the rate of applied N was increased, but the smoke tar was lower at the two intermediate levels.

PLANT SCIENCE

Ethrel

Two days after they were sprayed with Ethrel, tobacco leaves showed no effects, but leaves harvested at that time yellowed 24 hr sooner and their grade indexes were as much as 10 cents/kg lower than those of untreated leaves. Similar results were obtained by harvesting after the effect of Ethrel became apparent in the field, that is, 3 or 4 days after treatment. Certain analogues of Ethrel affected color change and grade index less than the commercial Ethrel. The response of leaves to Ethrel was found to be related to weather conditions at the time of application.

Harvesting Leaves

A standard variety, Delhi 34, and a yellow mutant, TI.14, were both fertilized at two rates, topped at two heights, and harvested in one or two passes. Duplicate plots of Delhi 34 were sprayed with Ethrel 2 days before harvest of the second pass of two-pass treatments. At this time, no leaves had been removed from one-pass treatments. Similar grade indexes were obtained from one- and two-pass harvests, except where Ethrel had been applied. Ethrel reduced the grade index of one-pass treatments, but had little effect on that of two-pass treatments. TI.14 had a lower yield and grade index than Delhi 34. Yield was increased and grade index decreased in both varieties when topping height was increased. Variations in fertilizer had little effect on yield or grade index.

Harvesting and Curing the Whole Plant

Chopping the entire plant at harvest is a new method that promises to reduce the cost of production and to increase the yield. Research has been directed toward the development of production equipment, facilities, and techniques that will result in a product that is acceptable for use in tobacco sheet. A lot of progress was made during 1973 by comparing the effects of different forage harvesters, variable cutting speeds, plant populations, cultivars, topping heights, and rates of fertilizer on the color and chemical composition of the cured product.

Physical Analysis

Firmness of cigarettes increased with increased compression distance, pressure drop through the cigarettes, and cut width of tobacco shreds, and it was highly correlated, positively, with force readings obtained when shredded tobacco was compressed.

PLANT PHYSIOLOGY

Physiological Maturity

Tobacco grown under field conditions showed distinct variation in physiological maturity, when measured by the plastochron leaf index. There can be up to 7 days difference in maturity at any time during harvest. The observed variation of plant maturity reflected variations in chemical composition, physical properties, and quality.

Translocation of DDT

Tobacco can readily take up and translocate *p,p'*-DDT; the extent of uptake is greatly dependent on availability from the growth medium. Soil has a great affinity for DDT, and only very limited amounts are released for plant uptake. The mechanism of absorption and the subsequent release of DDT are not completely understood.

The distribution of DDT within plants grown under controlled conditions has been established to be very similar to that of DDT in field-grown plants. Approximately 80% of total DDT isomers in field-grown plants was recovered from the root system. Plants grown under controlled conditions showed somewhat higher proportions of DDT in the root, but the distributions were similar. Evidence suggested that most of the available DDT accumulated in the root system and returned

to the soil after harvest was complete, when the roots decomposed in the soil. This cycling of the DDT between the soil and the root and back to the soil, and the chemical stability of the DDT molecule, resulted in its prolonged persistence and relatively long half-life in the soil.

Analysis of Leaf Position

Paired-leaf harvesting of Virginia 115 showed that smoke tar and nicotine per cigarette increased linearly with stalk position by 119% and 85%; similar increases of 90% and 57% were found for Delhi 34. These results emphasize an increased variability for smoke tar and nicotine based on stalk position for Virginia 115 over Delhi 34. The lowest ratio of smoke tar to nicotine was usually found in the sand leaves, and the highest ratio was in the 11th to 14th leaves of both varieties. The combined ratios of leaf tar to nicotine were 12.5 and 15.6 for Delhi 34 and Virginia 115, with the upper eight leaves of Virginia 115 mainly accounting for the difference in the ratios.

Bioassay Program

Early results suggest that a variety low in smoke tar tends to produce a lower biological activity than one that is high in tar. These results were determined by means of the short-term bioassay test of sebaceous gland suppression and epidermal hyperplasia in mice.

GENETICS AND PLANT BREEDING

Interspecific Gene Transfer

Two varieties of *Nicotiana rustica* L. (NRT and Babor), when used as pistillate parents in crosses with four tetraploid (4*n*) cultivars of *N. tabacum* L. (Delhi 34, Virginia 115, Delcrest 66, and Strain 205), produced partially sterile interspecific hybrids. A single backcross to their respective normal diploid (2*n*) parents, *N. tabacum*, produced 159 progenies.

Agronomic characteristics of each individual progeny differed vastly. Chemical analyses of the three flue-cured leaves from the mid position of each plant indicated alkaloid contents of 1.01–8.05%. Of the 159 progenies, 50 had alkaloid contents over 3.75%.

About one-third of the high-alkaloid individuals contained 5–8% alkaloid. This suggested that new alkaloid genes from the *rustica* sources are contained in the *tabacum* type segregants due, possibly, to homologous pairing and subsequent exchange of chromosomal segments between the *N. tabacum* and *N. rustica* genomes.

However, first-backcross progenies (BC₁) are still highly sterile and are being backcrossed with Lonibow, a very low nicotine flue-cured *tabacum* variety, to restore fertility and to isolate the segregants with new alkaloid genes.

Evaluation of New Varieties

In the evaluation of new flue-cured varieties from foreign sources, the two U.S. varieties Cokers 347 and Speight G41 were most productive in yield and crop returns. They matured slower than Canadian varieties and unfortunately flowered 5 to 7 days later than the standard variety Delhi 34. Speight G41 suffered from leaf drop and tended to produce more dark-colored tobacco. The Indian varieties Dhanadayi and Kanaka Prabha were satisfactory in leaf quality, were low in yield, and had fairly high tolerance for black root rot, but their smoking qualities were most undesirable and, consequently, both varieties were discarded. Although the German variety S.C.R. was favorable in leaf and smoking quality, it was low in yield and in tolerance for black root rot. Several U.S. varieties were later in maturity, lower in leaf quality, and low in tolerance for the diseases black root rot and weather fleck.

Smoke Characteristics of Variable Alkaloid Varieties

In an evaluation study of the smoke of 13 varieties and strains of flue-cured tobacco having total alkaloid contents of 0.14–3.66%, significant differences were found among the entries in total particulate matter (TPM), smoke nicotine, wet tar, and number of puffs per cigarette. When the data were calculated on the basis of 1 g of tobacco smoked, significant differences were found among the entries for TPM and smoke nicotine. The low-nicotine varieties, Lonibow, Vinca, and Strain 205, produced significantly lower TPM, wet tar, and smoke nicotine per cigarette than the higher nicotine lines, Hicks Broadleaf and Strain M3-2. Both variables,

wet tar per cigarette and TPM per gram of tobacco smoked, were positively correlated with TPM per cigarette, nicotine per cigarette, wet tar per gram of tobacco smoked, percentage of total alkaloids in the leaf, and weight of leaf lamina; and negatively correlated with weight of tobacco per cigarette, pressure drop, and number of puffs per cigarette.

PLANT PATHOLOGY

Black Root Rot

Fumigation in the row with chloropicrin at 22.46 litres/ha (2 gal/ac) and Terr-O-Cide 30 at 89.84 litres/ha (8 gal/ac) in sandy loam soil heavily infested with *Thielaviopsis basicola* (Berk. & Br.) Ferr. reduced root lesions by 45% and increased plant weight by 100% and 80%. Chloropicrin treatment had no effect on leaf or smoke quality.

The application of benomyl and thiophanate-methyl in the planting water was less effective in controlling the disease. Benomyl at 125 ppm reduced root lesion rating by 30% and increased plant weight by 40%. In the laboratory, benomyl applied at 33 and 66 mg/kg of organic soil infested with *T. basicola* reduced the population of the pathogen for 6 mo by 70% and 90%.

Damping-off

Isolates of *Pythium* from diseased tobacco seedlings were identified as *P. ultimum* Trow, the first record of this species on tobacco in Canada. Captan, UniRoyal 2030 (Vitavax + captan), and Daconil were effective in suppressing *P. ultimum* growth in culture. UniRoyal 2030 was also effective against *Rhizoctonia*. In the greenhouse, muck treated with UniRoyal 2030 at up to 50 g/93 m² showed no phytotoxic effect, whereas at double the rate the effect was slightly toxic. PP395 was effective against *Pythium* in culture and its effect was not changed when used with benomyl.

A laboratory study of leaf disks in a controlled environment showed that more pole rot, caused by *Rhizopus arrhizus* Fischer, developed on sand leaves and tip leaves than on cutter and middle leaves. Fumes of formaldehyde and Fumite effectively reduced the severity of the disease without damaging the leaves.

In a three-tier curing chamber, tobacco laths exposed to Fumite and formaldehyde

fumes for 30 min before curing reduced the severity of pole rot on leaves of the lower, and probably the middle, but not the upper tier.

When tobacco leaves were tied to a lath with twine treated with dichloran, pole rot was less severe than when the leaves were tied with untreated twine.

ENTOMOLOGY

Cutworms

A field study on the hatching rate of overwintered eggs of the darksided cutworm, *Euxoa messoria* (Harris), was started in 1968. Overwintered eggs began to hatch as early as March 27 in 1968 and as late as April 14 in 1972, depending upon the weather; hatching was completed about April 22.

Laboratory tests to determine the toxic action of chlorpyrifos on fourth- to sixth-instar larvae of *E. messoria* showed that the first day after treatment more larvae died faster from the toxic action in the stomach

than from the fumigant or contact action. The toxic action in the stomach was the most effective treatment for killing the larvae during this study.

Five chemicals were tested in a field for control of *E. messoria* larvae after transplanting. Leptophos 3 emulsifiable concentrate (EC) and 45% wettable powder (WP) gave the best control of *E. messoria* larvae, but the 3 EC formulation injured the tobacco seedlings. Endosulfan, N-2596, and trichlorfon were more effective than carbaryl, which is currently recommended, and they had no visible effect on the tobacco seedlings.

Root Maggots

Chlorpyrifos, CGF-2600, diazinon, fonofos, leptophos, and Vydate were applied in planting water for control of *Hylemya* spp. on flue-cured tobacco. All materials significantly reduced the number of tunneled plants as compared with the untreated control, and CGF-2600 at 0.73 kg/ha (0.65 lb/ac) was numerically the most effective treatment and gave the highest yield and crop index.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	Manufacturer
CGF-2600	Ciba-Geigy Canada Ltd.
Daconil	Diamond Shamrock Chemical Co.
DD	Shell Canada
Ethrel	Amchem Products Inc.
Fumite	Chipman Chemical Co.
Mocap	Mobil Chemical Co.
N-2596	Stauffer Chemical Company
PP395	Chipman Chemical Co.
Telone	Dow Chemical of Canada Ltd.
Telone C	Dow Chemical of Canada Ltd.
Terr-O-Cide	Great Lakes Chemical Corporation
UniRoyal 2030 (Vitavax + captan)	UniRoyal Chemical Co.
Vitavax	UniRoyal Chemical Co.
Vorlex	Nor-Am Agricultural Products Ltd.
Vydate	DuPont of Canada Ltd.

PUBLICATIONS

Research

- Cheng, H. H. 1973. Further field evaluation of insecticides for control of the dark-sided cutworm (Lepidoptera: Noctuidae) on tobacco in Ontario. *Can. Entomol.* 105:1351-1357.
- Cheng, H. H. 1973. Laboratory and field tests with *Bacillus thuringiensis* against the dark-sided cutworm, *Euxoa messoria* (Lepidoptera: Noctuidae), on tobacco. *Can. Entomol.* 105:941-945.
- Cheng, H. H. 1973. Observations on the bionomics of the dark-sided cutworm, *Euxoa messoria* (Lepidoptera: Noctuidae), in Ontario. *Can. Entomol.* 105:311-322.
- Gayed, S. K. 1972. The effect of deep fumigation on yield of flue-cured tobacco in Ontario. *Tob. Sci.* 16:169-171.
- Marks, C. F., and Elliot, J. M. 1973. Damage to flue-cured tobacco by the needle nematode *Longidorus elongatus*. *Can. J. Plant Sci.* 53:689-692.
- Olthof, T. H. A., Marks, C. F., and Elliot, J. M. 1973. Relationships between population densities of *Pratylenchus penetrans* and crop losses in flue-cured tobacco in Ontario. *J. Nematol.* 5:158-162.
- Rosa, N. 1973. Sampling of *Nicotiana tabacum* L. leaf lamina to surmount the problem of non-uniform distribution of total alkaloids. *Can. J. Bot.* 51:289-291.
- Rosa, N., and Cheng, H. H. 1973. Uptake of DDT by *Nicotiana tabacum*. *Can. J. Plant Sci.* 53:443-446.
- Cheng, H. H. 1973. Microplot test using microbial and chemical insecticides for control of tomato hornworms on tobacco in Ontario. *The Lighter* 43(3):10-13.
- Elliot, J. M. 1973. A survey of flue-cured tobacco grown in Ontario in 1972. Part I: Nitrogen, alkaloids, sugars, filling value, and lamina weight. *The Lighter* 43(1):25-27.
- Elliot, J. M. 1973. A survey of flue-cured tobacco grown in Ontario in 1972. Part II: Soil characteristics, nutrient elements, and smoke analysis. *The Lighter* 43(4):11-16.
- Elliot, J. M. 1973. Nematicides for control of nematodes. *The Simcoe Reformer, Tobacco Ed.*
- Gayed, S. K. 1973. The effect of chemicals on weed population in tobacco seed-beds. *The Lighter* 43(1):28-31.
- Gayed, S. K. 1973. Viruses—Possible threat to tobacco. *The Can. Tobacco Grower* 21(5):15 and 18.
- Marks, C. F., and Elliot, J. M. 1973. Nematicides in the soil environment. *The Lighter* 43(2):18-20.
- Scott, W. A., and Elliot, J. M. 1973. A survey of burley tobacco grown in Ontario in 1972. *The Lighter* 43(4):17-21.
- Walker, E. K. 1973. Comparison of flue-cured tobacco transplants variable in time of transplanting and method of culture. *The Lighter* 43(3):18-23.
- Walker, E. K. 1973. Some causes of poor cures. *The Simcoe Reformer, Tobacco Ed.*
- Walker, E. K. 1973. Time of transplanting and hardening of transplants. *The Simcoe Reformer, Tobacco Ed.*
- White, F. H. 1973. Comparison of Canadian and American seed sources of the flue-cured tobacco variety, Virginia 115. *The Simcoe Reformer*, Jan. 23.
- White, F. H. 1973. Evaluation of new variety introductions. *The Lighter* 43(2):10-15.
- White, F. H. 1973. Flue-cured tobacco varieties are compared and evaluated. *The Simcoe Reformer, Tobacco Ed.*
- White, F. H. 1973. Variety development and testing. *The Tillsonburg News, Tobacco Ed.*

Miscellaneous

Research Station Harrow, Ontario

PROFESSIONAL STAFF

G. C. RUSSELL, B.S., M.S., Ph.D.	Director
D. H. LEE	Administrative Officer
K. M. SUTHERLAND (Miss), B.S., B.L.S.	Librarian

Chemistry and Weed Science Section

G. M. WARD, B.Sc., M.A., Ph.D.	Head of Section; Greenhouse crops nutrition
A. S. HAMILL, B.Sc., M.Sc., Ph.D.	Weed ecology
P. B. MARRIAGE, B.S.A., M.S., Ph.D.	Weed physiology
F. G. VON STRYK, Dipl. Chem., Ph.D.	Pesticide chemistry

Crop Science Section

C. G. MORTIMORE, B.S.A., M.S.	Head of Section; Corn breeding
L. J. ANDERSON, B.S.A.	Varietal evaluation
J. W. AYLESWORTH, B.S.A., M.S., Ph.D.	White bean breeding
B. R. BUTTERY, B.Sc., Ph.D.	Soybean physiology
R. I. BUZZELL, B.S., Ph.D.	Soybean breeding
W. A. SCOTT, B.S.A.	Burley tobacco management

Entomology Section

W. M. ELLIOTT, B.Sc., Ph.D.	Vegetable insects
W. H. FOOTT, B.S.A., M.S.A., Ph.D.	Field and vegetable crop insects
R. P. JAQUES, B.S.A., M.S.A., Ph.D.	Insect pathology
R. J. McCLANAHAN, B.A., M.Sc., Ph.D.	Greenhouse insects
B. C. SMITH, B.A.	Ecology of field crop insects

Horticultural and Soil Science Section

J. M. FULTON, B.Sc., M.S.A., Ph.D.	Head of Section; Soil moisture and irrigation
E. F. BOLTON, B.S.A., M.S.A., Ph.D.	Soil management

W. I. FINDLAY, B.Sc., M.Sc., Ph.D.
 R. E. C. LAYNE, B.Sc., M.S., Ph.D.
 V. W. NUTTALL, B.S.A., M.S.A.
 H. A. QUAMME, B.S.A., M.Sc., Ph.D.

Soil fertility
 Tree fruit breeding
 Vegetable breeding
 Tree fruit breeding

Plant Pathology Section

B. N. DHANVANTARI, B.Sc.; M.Sc., Ph.D.
 W. G. BONN, B.Sc., M.S., Ph.D.
 L. F. GATES, B.S., Ph.D.
 J. H. HAAS,¹ B.S., Ph.D.
 P. W. JOHNSON, B.S.A., M.Sc., Ph.D.

Tree fruit diseases
 Bacterial diseases
 Cereal viruses and corn diseases
 Soybean and white bean diseases
 Plant parasitic nematodes

Soil Substation, Woodslee, Ontario

J. W. AYLESWORTH, B.S.A., M.S., Ph.D.

Officer in Charge

Departures

J. DUECK, B.S.A., M.Sc., Ph.D.
 Resigned March 23, 1973

Bacterial diseases

J. HOPKINS, B.Sc. (Agr.)
 Resigned June 15, 1973

Fruit crops

W. E. KAYLER, B.Sc. (Agr.), M. Dipl.
 Resigned October 12, 1973

Vegetable crops

C. D. McKEEN, B.A., M.A., Ph.D.
 Transferred; Research Coordinator, Ottawa, Ont.,
 June 8, 1973

Head of Section; Vegetable
 diseases

C. D. F. MILLER, B.S.A., M.S.A., Ph.D.
 Transferred; Research Coordinator, Ottawa, Ont.,
 April 23, 1973

Head of Section; Cereal and
 forage crop insects

W. J. SAIDAK, B.S.A., M.S., Ph.D.
 Transferred; Research Coordinator, Ottawa, Ont.,
 June 25, 1973

Weed science

R. N. WENSLEY, B.S.A., Ph.D.
 Retired October 31, 1973

Soil microbiology

H. B. WRESSELL, B.S.A.
 Retired April 30, 1973

Field and vegetable crop insects

EXTENSION SERVICES²

J. C. FISHER, B.S.A.

Greenhouse and vegetable crops

K. H. FISHER (Miss), B.Sc. (Agr.), M.Sc.

Fruit and vegetable crops

¹On a transfer of work from July 1, 1973 to June 30, 1974 at the Agricultural Research Organization,
The Volcani Center, Bet-Dagan, Israel.

²Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Research Station at Harrow is located in southwestern Ontario where a diversified agricultural industry involves a greenhouse industry and the production on a large scale of a large number of field, fruit, and vegetable crops. The plant breeding programs at the Station in tree fruits, and field and horticultural crops resulted in the release in 1973 of a new variety of white bean named Kentwood and of two new corn hybrids. Programs on disease, insect, and weed control for a number of crops such as corn, soybeans, tomatoes, and other field and horticultural crops have produced results modifying and improving recommended practices for such control. Crop management studies dealing with fertilizer application practices, plant population and spacing, or harvesting practices with crops such as asparagus, cucumbers, cabbage, tomatoes, and corn have led to more economical production practices for these crops.

This report deals with some of the highlights of the results of research in 1973. More detailed results may be found in the journals and reports listed under Publications. For more information on projects or for reprints of published papers write: Research Station, Research Branch, Agriculture Canada, Harrow, Ont. N0R 1G0.

G. C. Russell
Director

FIELD CROPS

Burley Tobacco

Fertilization. In a 5-yr experiment the yields of cured, burley tobacco leaf were approximately 2,800, 3,030, 3,140, and 3,250 kg/ha (2,500, 2,700, 2,800, and 2,900 lb/ac) for N fertilizer applied at 84, 140, 196, and 252 kg/ha (75, 125, 175, and 225 lb/ac) respectively, with P fertilizer at a basal 168 kg/ha (150 lb/ac) and K fertilizer at 252, 420, or 588 kg/ha (225, 375, or 525 lb/ac). The 420- and 588-kg rates of K increased yield only 3–4% over basal yield even when applied with 252 kg/ha of N. The grade value of tobacco leaf was depressed 4–6% when N application exceeded 140 kg/ha, but grade value did not change with an increase in rate of K fertilizer.

Cereals and Forages

Viruses. Wheat spindle streak mosaic infected an average of 39%, 46%, and 30% of the shoots in Essex, Kent, and Lambton counties respectively. Neither fumigation with Vorlex (Nor-Am Agricultural Products Ltd.) nor plowing in a green crop of kale shortly before planting affected disease incidence. Five varieties showed markedly less spindle streak mosaic than 15 others. Crosses were made between the most resistant variety, Halytchanka, and three commercial varieties.

This year's surveys of alfalfa mosaic in alfalfa crops have confirmed infection levels of about 10% in first year's crop and 40% in crops in their second or later years.

Corn

Breeding. Based on their performance in the Ontario corn tests in 1972 and 1973, two Harrow hybrids, 721 and 725, were declared eligible for license and the recommended list by the Ontario Corn Committee. Production rights for Harrow 721 have been granted to United Co-operatives of Ontario, who will market the hybrid as Co-op 320. Rights to Harrow 725 were granted to Otto Pick & Sons Ltd., and it will be marketed as Pick-seed 185. In addition to high yields both hybrids exhibited good standability.

Herbicide residues in drainage water. Atrazine residues measured in tile runoff effluent from corn plots, continuous or in rotation, were in the parts per billion level and are considered to constitute only a minimal source of pollution in agricultural areas.

Insects. Damage from the northern corn rootworm was negligible in 1973, even in fields not treated with a pesticide. In spite of this, soil pesticides were widely used by farmers. The development of a method to predict damaging populations is under investigation.

Leaf blights. Counts of viable *Helminthosporium turcicum* Pass. spores on corn residues in the field declined to very low levels over the winter, but viable spores were detected in May. Fungi with the spore type of *H. maydis* Nisik. & Miyake were frequently isolated from small lesions on corn with N cytoplasm, but no isolates were found that attacked corn with N cytoplasm to the same extent as corn with T cytoplasm.

Movement of nitrate-N in sandy soils. Nitrogen accumulation in a coarse-textured soil was studied in a field of corn by taking soil samples to a depth of 2.7 m (9 ft) and water samples from wells 6.4 m (21 ft) deep. In mid-July 1972, the soil profile contained 119, 213, 399, and 558 kg/ha (106, 190, 356, and 498 lb/ac) nitrate-N on plots that had been fertilized annually at planting time since 1970 with N at 0, 112, 224, and 336 kg/ha (0, 100, 200, and 300 lb/ac) respectively. In mid-June 1973, one month after application of the annual treatments, the plots contained N at 62, 104, 180, and 337 kg/ha (55, 93, 161, and 301 lb/ac). This decline in nitrate level may be evidence of leaching losses. Although no significant concentration of nitrate-N has been found in the well waters, it is suggested that extensive dilution could have occurred. The water table at this site rose in 1973 to 2.7 m (9 ft), up from 4.1 m (13.5 ft) in 1972.

Nutrient leakage. Measurement of nutrients in drainage effluent indicated that recommended rates of fertilizer applied for corn on Brookston clay did not produce significant changes in P and nitrate-N compared with nutrients originating from unfertilized areas. The yield data showed that recommended fertilizer applications, especially N, were essential to produce commercial yields of corn.

Root and stalk rot. Ear development in the 2 wk after mid-silk was most rapid for Pioneer 3773 and least rapid for B14 × CH9, in line with eventual stalk rot. Pith in the lower parts of the stalks of hybrids deteriorates rapidly in this period, and the more rapid ear development may accentuate early deterioration of pith cells.

Tile spacing. Corn yield data for 1972 and 1973 on Brookston clay soil at Oil City indicated a marked yield increase as the distance between tile decreased. Yield on 6.1 m spacing averaged 7,030.9 kg/ha and

decreased to 4,729.1 kg/ha at 15.2 m spacing where it appeared to level off. The observed yield responses to tile drainage were especially noteworthy because there were no periods of excessive rainfall in either season.

Weed control. The relatively new herbicide Roundup (Monsanto Canada Ltd.) has been tested in greenhouse and field and has given excellent control of Canada thistle. It has proved to be as effective as amitrole and leaves no soil residue. Shoots are completely killed in 3 wk and roots within 1 mo. A combination herbicide, Ekko (atrazine + simazine; Ciba-Geigy Canada Ltd.) gave excellent control of a wide range of weeds. Bladex (Shell Chemical Co.) gave effective control of velvetleaf. Two promising new chemicals are CGH 2430 and CGH 3680 (Ciba-Geigy Canada Ltd.).

Soybeans

Biochemical genetics. Previous studies at the Station have shown that nine flavonol glycosides occur in various soybean cultivars. The sugars of these glycosides have been identified, and their inheritance has been determined. A monoglucoside is the basic glycoside; it is present even when the four flavonol glycoside genes are recessive. The dominant alleles of these four genes control, probably through appropriate glycosyltransferases, the addition of glucose or rhamnose units to the glucose of the monoglucoside in the formation of four diglycosides and four branched triglycosides. Gene *Fg1* adds a glucose by a β (1-6) linkage (i.e., position 6 of the basic glucose) to form the gentiobioside, *Fg2* adds rhamnose γ (1-6) to form the rutinoid, *Fg3* adds glucose β (1-2) to form the sophoroid, and *Fg4* adds rhamnose γ (1-2) to form the neohesperidoid. In gene combinations, *Fg1* plus *Fg3*, *Fg1* plus *Fg4*, *Fg2* plus *Fg3*, and *Fg2* plus *Fg4* form the 2^G-glucosyl gentiobioside, the 2^G-rhamnosyl gentiobioside, the 2^G-glucosyl rutinoid, and the 2^G-rhamnosyl rutinoid respectively. In the other two gene combinations, *Fg1* and *Fg2* both involve a 1-6 linkage, whereas *Fg3* and *Fg4* both involve a 1-2 linkage; thus no triglycosides are formed because the same position of the basic glucose is involved in each case. Various flavonol glycoside genotypes were tested in the field; *Fg1 Fg3* had a lower photosynthetic rate (P), lower specific leaf weight, and lower chlorophyll content than the other genotypes. The simplest

interpretation is that kaempferol 2^G-glucosyl gentiobioside has an inhibitory effect on P or on chlorophyll formation.

Weed control. Control of velvetleaf was obtained with Sencor (Chemagro Corp.) or Basagran (BASF Corp.) alone or in combination with other herbicides. When Sencor was used with soybeans on soil formerly treated with atrazine, it produced slight injury and delayed maturity but did not affect yield.

White Beans

Breeding. Kentwood, a new variety developed at the Station, was licensed and released to seed growers in 1973. It has resistance to the alpha, beta, and gamma races of *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav. and to strains 1 and 15 of common bean mosaic. In the root-rot nursery here, Kentwood has shown more tolerance than Sanilac and Seafarer. In 23 tests at four locations over 5 yr Kentwood averaged 4.0% and 7.0% higher in yield than Sanilac and Seafarer respectively. In 1973 when root rot and bronzing were more severe, Kentwood averaged 16% higher in yield than these two varieties. It is a bush type, which matures 1 to 2 days earlier than Sanilac and has slightly larger seed than Seafarer. Kentwood tends to hold the pods off the ground, and this would result in better seed quality during adverse harvest conditions.

HORTICULTURAL CROPS

Field Vegetables

Asparagus

Harvest duration and yields. There was an interaction between cultivars and harvest durations. Nine cultivars produced less in 52 than in 60 days; the yields of three were reduced by 561 kg/ha. A 68-day harvest depressed yields by as much as 538 kg/ha. Three cultivars produced lowest, intermediate, and the greatest yields respectively at the 52-, 60-, and 68-day harvest durations.

Pesticide residues. Recommended treatments for asparagus beetles resulted in residues below the tolerance level 24 h later. The rate of disappearance was fast for malathion and slightly slower for carbaryl, methoxychlor, and rotenone.

Baby Carrots

Succession cropping and seeding rates. Two years' trials showed that succession cropping is probably feasible on organic soils in the Point Pelee marsh near Leamington, Ont. In 1972, baby carrots were successful after sett onions; in 1973, a fall crop was seeded July 25 after the spring crop. Of five cultivars, Amsterdam Coreless Forcing gave the best yield at the highest of three seeding rates: 538, 860, and 1,182 seeds/m².

Cabbage

Insect pathology. Field tests showed that a heavy application of the viruses of the cabbage looper and cabbageworm followed by two late-season applications of a chemical insecticide or *Bacillus thuringiensis* Berliner was as effective as five applications of the latter materials in the control of the cabbage looper and cabbageworm on late cabbage. This indicated the crop protection effected by the viruses established in the field early in the crop season.

A new formulation of *B. thuringiensis* and a broad-spectrum virus (the nuclear-polyhedrosis virus of *Autographa californica* [Speyer]) were highly effective in the control of the cabbage looper.

Maggot control. The recommended planting drench treatments provided 100% control, but untreated plants were severely damaged. Two experimental treatments were as effective, but four others allowed some damage.

Cucumber

Breeding, testing, and management. Selections were made for white-spine pickling types tolerant of angular leaf spot, *Pseudomonas lachrymans* (Sm. & Bryan) Carsner, and for earlier monoecious pollinators to advance fruit set and harvest by 1 wk in commercially grown gynoecious hybrids. Harrow H71.21 F hybrid pickler was increased for extensive testing in 1974.

Early-Pik and Pickmore cultivars are presently the best for both hand and machine harvest in southwestern Ontario. On Fox sandy loam, plant stress at 247,100 plants/ha results in shorter fruits, a smaller proportion of high-priced grades, and faster yellowing. Using Early-Pik at 148,260, 197,680, and 247,100 plants/ha, gross returns were \$2,068, \$1,932, and \$1,752/ha respectively.

Sweet Corn

European corn borer control. A number of insecticides provided good control of the first generation of borers, but with a very heavy second generation a 5-day spray schedule proved inadequate even with the best insecticide.

Tomatoes

Cultivation for tomatoes. One or more shallow cultivations increased tomato yield over the uncultivated check in 1973, similar to the results of most previous years. The greatest effect was at early harvest, Sept. 5, where yield after three shallow cultivations was more than 6.7 t/ha greater than on the uncultivated check where weeds had been controlled with chemicals alone. To ensure that weed growth was not a factor influencing results, any further weed growth on the check or cultivated treatments was removed by surface scraping with a hoe.

Insects. Previous work showed that *Glischrochilus quadrisignatus* (Say), a nitidulid beetle that infests damaged processing tomatoes, breeds in ears of corn. Burial of the ears in the fall or spring at depths of 7.6 and 15.2 cm (3 and 6 in.) did not prevent oviposition. Recent work showed that if the ears could be broken up by some type of machinery into partial ears before burial, the reproductive potential of the beetle would be greatly reduced. Treatment of hampers with malathion ultralow volume 95% technical gave good control of beetles when damaged tomatoes occurred only on the bottom of the hamper, moderate control when damaged tomatoes were distributed throughout the hamper, and poor control when damaged tomatoes occurred only in the upper and central parts of the hamper.

Root distribution. The vertical and horizontal distribution of processing tomato roots was measured in the field four times during the season. The maximum number of roots appeared about July 18, and the number decreased thereafter. The maximum depth of rooting was very similar to that of potatoes, cucumbers, field corn, and early tomatoes, measured earlier. The horizontal distribution of processing tomato roots was very dense near the surface but decreased sharply to a depth of about 20 cm and then remained more or less constant to 40 cm. The total number of roots exposed in a cross section of

the tomato root zone was much less than for corn. This latter observation appears to explain the fact that tomatoes extract 5 cm of soil water compared with 7.5 cm for corn without restricting yield.

Weed control. Sencor as a postemergence spray gave effective control of all weeds except black nightshade. As a preplant application it gave better control when combined with some other herbicides.

Greenhouse Vegetables

Cucumber

Breeding and testing. At two locations, Harrow HG70.72 seedless F hybrid equaled Toska 70 in numbers and weight of fruits per plant. HG70.72 was increased for commercial greenhouse and market acceptance tests in Ontario and for further trials in the USA and Europe. After 14 days in storage at 12.3°C and 81% relative humidity, the residual shelf life of HG70.72 and other Harrow lines was superior to that of Toska 70. Best storage appeared to be associated with skin thickness. Using an Ottawa Texture Measurement System with a 0.16-cm diam steel probe, the average force for three-position skin punctures (stem and blossom ends and center) of fresh, unpeeled fruits, for the firmest to the least firm was HG72 (981), HG73 (910), HG70.72 (833), and Toska 70 (816 g).

Pruning seedless cucumbers to either main-stem fruit production or the conventional pruning resulted in no significant yield differences between methods. This is contrary to results in Holland where gynoeious types with laterals removed set more fruits.

Calcium deficiency. A sand culture study with both seeded and seedless cucumbers confirmed the observation that cucumber fruits do not develop a condition similar to blossom-end rot on tomatoes or peppers. Under severe deficiency the symptoms are curled leaves and aborted growing tips, and any fruits that set remain small and become deformed with constricted blossom end or center. Small deformed fruit from calcium-deficient plants had a calcium content of 0.05-0.06% compared with 0.45-0.55% in mature normal fruit. Reduction in calcium content was found in all plant tissues.

Tomatoes

Cage plant. A cage plant, completely untrimmed, cultivar Vendor, was grown in one corner of a greenhouse remote from any competition from other plants for light or water. The cage, constructed of stakes and string, restrained side growth but permitted easy access for harvesting. A canopy at the top reached a spread of 3.7 m (12 ft) during the last 2 mo of growth occupying a space covered by 10 standard plants. The normal cultural practices of fertilizing, watering, and pollinating were followed. During the spring crop season, Jan. 15 to July 15, the plant produced 562 fruits weighing 51.48 kg (113.5 lb), and 501 marketable fruits weighing 45.32 kg (99.92 lb). This demonstrates the possible production capacity of one plant grown with no limit on light.

Leaf miner biological control. Two parasites of the vegetable leaf miner, *Liriomyza munda* Frick, provided considerable control of the pest in some greenhouse tomato crops. Colonies of the leaf miner and one of the parasites were established.

Nematodes. In microplot studies in a sandy loam greenhouse soil, the southern root-knot nematode, *Meloidogyne incognita* (Kofoed & White) Chitwood, moved vertically in both directions through a soil depth of 150 cm. High population densities of nematodes and root-gall indexes were recorded through depths of 150 cm in soil inoculated with 4,400 nematodes/kg in the top 30 cm or 120–135 cm below the surface. In the top 30 cm of soil this initial population density reduced tomato yield by 20% in the first crop and 70% in the second. Similar population densities 120–135 cm from the soil surface reduced tomato yield by 11% in the first crop and 59% in the second.

This rapid upward movement explains the short-term effect of greenhouse control measures and accounts for the recurring problem of infestation in many houses. Nematodes escape control at depths below which present control methods are effective and subsequently move up to infest the next crop.

Growers experiencing a recurring nematode problem can expect a 60–70% reduction in yield in infested areas if control measures are omitted before the next crop.

Supplementary light. In 1973 the growing season was exceptionally poor for greenhouse crops in Essex County. The spring crop

was grown with 15% less sunshine than the 54-yr average, and the distribution was uneven. An unusual amount of blossom abortion occurred and fruit size was reduced. Plants grown with the aid of supplementary artificial light from Jan. 15 to Mar. 15 by extending day length to 16 h produced a slightly higher yield than check plants without supplementary light. Fruit size was larger and the percentage of nonmarketable fruit was smaller. Mercury vapor lamps and fluorescent lamps produced about the same results. Two cultivars, Vendor and MR12, responded in a similar manner.

Translocation of benomyl. A study with radioactive tracers has shown that the fungicide benomyl and its metabolite, MBC (methyl benzimidazole-2-carbamate), are translocated more efficiently through tomato seedling tissues when applied as a foliar spray rather than as a soil drench.

Tree Fruits

Apricots

Presoaking and fall planting apricot seedling rootstocks. Four apricot seedling rootstocks were tested: Haggith, Toovey, Goldcot, and Earle Orange. The pits were planted after soaking for 0, 24, 36, or 48 h, or the pits were removed and the seeds similarly treated; then both groups were planted on Nov. 9, 1972. Emergence data were recorded in May and June 1973, and plant height and stem diameter were recorded in September. In general, fall planting of apricot pits gave acceptable stands of budable trees of Haggith (72%) and Goldcot (65.3%) the next year, but stands of Toovey (33.5%) and Earle Orange (23.0%) were not acceptable. Presoaking pits before planting improved emergence. Fall planting seeds gave poor stands with each rootstock, and presoaking of seeds had no appreciable effect on emergence.

Peaches

Cold hardiness of peach rootstocks. Three peach rootstocks were tested for hardiness by freezing intact root systems through a range of temperatures from -5 to -23°C in increments of 3°C . Cold hardiness was assessed by regrowth tests. Siberian C was significantly hardier than either Elberta or Bailey. It showed positive regrowth and new roots at

-17°C, whereas Bailey and Elberta did not, although they did at -14°C but to a lesser extent than Siberian C. Intact root systems of 1-yr-old nursery trees of Siberian C were frozen at -5 to -14°C, and 2-yr-old trees at -5 to -23°C. The lethal temperature for 1-yr-old roots was between -8 and -11°C and for 2-yr-old roots it was between -14 and -17°C. Thus, 2-yr-old peach roots could withstand about 6°C more cold than 1-yr-old roots.

Controlled freezing tests of hardy peach varieties and selections. Eleven of the hardiest peaches in the Harrow cultivar collection were tested for relative and absolute cold hardiness on Feb. 14, 1973. The lethal temperature for flower buds of Redhaven and Lemon Free was -20°C, but -26°C was lethal for Siberian, Babygold 8, Y322, Y461, Reliance, and Tzim Pee Tao, and -28°C was lethal for Bailey, Harrow Blood, and Y327. Maximum separation of varieties for bud hardiness at a single stress temperature occurred at -22°C. The hardiest varieties included Bailey, Y327, Siberian, and Tzim Pee Tao. Varieties differed significantly in wood hardiness. The widest separation in varieties occurred at -26°C. The hardiest varieties included Siberian, Y461, Y327, Tzim Pee Tao, and Harrow Blood, which sustained only very light to light tissue injury. Bailey and Y327 were next, then those with the most tissue injury (moderate to severe), Reliance, Babygold 8, Redhaven, and Lemon Free.

Effect of outdoor temperatures on cold hardiness acclimation of peach buds. Six cultivars were selected that represented the full range of cold hardiness recognized in the Harrow cultivar collection: (1) very hardy, Babygold 8 and Bailey; (2) hardy, Siberian C; (3) medium hardy, Redhaven; (4) medium tender, Elberta; (5) tender, Loring; and (6) very tender, Redglobe. They were tested for relative and absolute bud hardiness on Jan. 4 after a mild period with temperatures fluctuating between -6 and 11°C; then on Jan. 12 during a cold period with temperatures fluctuating between -12 and -3°C; and then again on Jan. 29 during another mild period with temperatures fluctuating between -8 and 9°C. The range in lethal temperatures among cultivars was relatively small (2 to 4°C) at any given time. During cold periods all varieties gained several degrees of cold hardiness, which were quickly lost during

mild periods. It appeared that varietal differences in rates of acclimation and deacclimation may have greater survival value than the ability to survive cold temperature by itself.

Herbicide residues in orchard soils. Examination of orchard soils treated with herbicides for a number of years showed that atrazine and simazine did not accumulate in the soil, but diuron, a urea type of herbicide, was considerably more persistent.

Nematode resistance of peach rootstocks. A preliminary study was conducted to test the resistance of 14 cold-hardy peach seedling rootstocks for resistance to *Pratylenchus penetrans* (Cobb), the most important nematode pest of peach in Ontario. The most resistant rootstocks with the lowest total increase in nematode population compared with the initial population included Yeh Hsiemtung Tao, H661511, H661203, Harrow Blood, and Y327. Siberian C was very susceptible. Further tests will be conducted in 1974 to refine techniques and reassess nematode resistance of the most promising stocks.

Peach bacterial spot. During the growing season of 1973, epiphytic populations of the causal organism *Xanthomonas pruni* (E.F.Sm.) Dowson were recovered from the surface of developing fruits of the susceptible Babygold 5 as well as the less susceptible Redhaven and the resistant Loring peach cultivars long before the appearance of fruit spots. In Babygold 5, a population of 10^6 was attained early in the season and was sustained throughout, whereas such a high level was reached only a week before harvest in Redhaven and Loring. Loring was characterized by carrying the lowest population most of the season. The microflora on the surface of the fruits, buds, and leaves consisted predominantly of *Erwinia herbicola* (Geiling) Dye, *Aureobasidium pullulans* (de Bary) Arn., *Rhodotorula*, and other yeasts.

Peach canker. Natural flower-bud mortality was related to incidence of cytospora canker at node and apex of peach shoots. Such cankers were fewer in the cultivars Bailey and Siberian C whose bud mortalities were 1 and 3% respectively and abundant in Redhaven, Loring, Redglobe with flower-bud mortalities of 17, 40, and 100% respectively. In controlled freezing and inoculation experiments, the number of such cankers generally increased with the increase in

flower-bud mortality. Water leachates of cold-injured buds stimulated the germ tube growth of spores of *Leucostoma cincta* (Fr.) Hohn. (*Cytospora cincta* (Fr.) v. Hohnel) and *L. persoonii* (Nits.) Hohn. (*Cytospora leucostoma* Sacc.), the causal fungi, suggesting the predisposing role of winter-injured tissue in canker incidence.

Peach crown gall. In an experiment designed to avoid unintentional wounding of potted plants, it was found that the root-knot nematodes *Meloidogyne hapla* Chitwood and *M. incognita* (Kofoed & White) and the root-lesion nematode *Pratylenchus penetrans* did not predispose peach plants (cultivar Rutgers Red Leaf) to crown gall by a virulent strain of *Agrobacterium tumefaciens* (Sm. & Towns.) Conn. Four months after soil inoculation it was found that the bacterium alone or in combination with any of the nematodes used had induced crown gall in 100% of the plants.

Peach rootstock influence on leaf nutrient levels of scion varieties. A study was initiated in 1973 to determine whether peach rootstocks influenced nutrient levels in the leaves of scion varieties, which in turn might influence scion growth, yield, and cold hardiness. Leaf samples were collected from Loring and Redhaven on each of four rootstocks: Harrow Blood, Siberian C, Rutgers Red Leaf, and Veteran; and from Babygold 5 on the same rootstocks and two others, Bailey and Halford. Peach rootstocks significantly influenced nutrient levels of leaves when sampled in June, July, and August. The nutrients affected depended on the scion as well as the rootstock. Elements that were consistently affected by rootstocks included potassium, calcium, magnesium, and zinc.

Peach rootstock influence on scion hardiness. Scions were collected from Loring, on

each of four seedling rootstocks at the end of February and frozen to several stress temperatures, and then assessed for bud mortality. There was a significant rootstock influence on bud hardiness of Loring. The least cold injury to Loring was sustained with Siberian and Rutgers Red Leaf as rootstocks and the most was recorded with Veteran and Harrow Blood.

Pears

Breeding. A total of 9,500 pear seedlings were screened for fire blight resistance and 2,000 were field planted. Three selections, designated H-300, H-301, and H-302, were propagated for advance trials. A series of dwarfing rootstocks for pear received from Oregon were also propagated for trial at the Station.

Fire blight. Work continued on development of a bactericidal dip for apples destined for export to countries free from fire blight. Several combinations of bactericides eliminated all bacterial cells under severe test conditions. Under more moderate test conditions a 10-min dip in 1.0 M acetic acid at room temperature provided satisfactory control.

The populations of the fire blight organism, *Erwinia amylovora* (Burr.) Winslow et al., on leaves of symptomless branches of pear and apple was monitored on a weekly basis from mid-June to early October. Detectable populations first noted in mid-June increased to higher levels in late July and early August. Bacteria were not detected in either September or early October. Twig blight counts in pear revealed an association between the presence of bacteria on leaf surfaces and shoot blight.

Assays for *E. amylovora* in dormant buds of pear revealed that the bacterium was present in the buds of Old Home and Flemish Beauty in February and March and in Flemish Beauty in April.

PUBLICATIONS

Research

Bolton, E. F., and Aylesworth, J. W. 1973. Use of black polyethylene mulch to reduce flooding effects on tomato yields. Can. J. Plant Sci. 53:857-861.

Buttery, B. R., and Buzzell, R. I. 1973. Varietal differences in leaf flavonoids of soybeans. Crop Sci. 13:103-106.

Dueck, J., and Quamme, H. A. 1973. Fire blight in southern Ontario in 1972. Can. Plant Dis. Surv. 53:101-104.

- Elliott, W. M. 1973. A method of predicting short term population trends of the green peach aphid, *Myzus persicae* (Homoptera: Aphididae), on potatoes. *Can. Entomol.* 105:11-20.
- Elliott, W. M., and Dhanvantari, B. N. 1973. Tree cricket (Orthoptera: Oecanthidae) damage to young peach trees. *Can. Entomol.* 105:1035-1038.
- Findlay, W. I. 1973. Influence of fertilizer use on the phosphorus and potassium status of sandy soils. *Can. J. Soil Sci.* 53:103-110.
- Foott, W. H., and Timmins, P. R. 1973. Effects of infestations by the corn leaf aphid, *Rhopalosiphum maidis* (Homoptera: Aphididae), on field corn in southwestern Ontario. *Can. Entomol.* 105:449-458.
- Fouk, J. 1973. Modification of a knapsack sprayer for more efficient use. *Can. J. Plant Sci.* 53:419.
- Gates, L. F. 1973. Incidence of wheat spindle streak mosaic in Essex, Kent, and Lambton counties, Ontario, 1969-72. *Can. Plant Dis. Surv.* 53:58-59.
- Hamill, A. S., and Penner, D. 1973. Butylate and carbofuran interaction in barley and corn. *Weed Sci.* 21:339-342.
- Hamill, A. S., and Penner, D. 1973. Chlorbromuron-carbofuran interaction in corn and barley. *Weed Sci.* 21:335-338.
- Hamill, A. S., and Penner, D. 1973. Interaction of alachlor and carbofuran. *Weed Sci.* 21:330-335.
- Hunter, R. B., Mortimore, C. G., and Kannenberg, L. W. 1973. Inbred maize performance following tassel and leaf removal. *Agron. J.* 65:471-472.
- Jaques, R. P. 1973. Methods and effectiveness of distribution of microbial insecticides. *Ann. N.Y. Acad. Sci.* 217:109-119.
- Jaques, R. P. 1973. Tests on microbial and chemical insecticides for control of *Trichoplusia ni* (Lepidoptera: Noctuidae) and *Pieris rapae* (Lepidoptera: Pieridae) on cabbage. *Can. Entomol.* 105:21-27.
- Johnson, P. W., and McKeen, C. D. 1973. Vertical movement and distribution of *Meloidogyne incognita* (Nematodea) under tomato in a sandy loam greenhouse soil. *Can. J. Plant Sci.* 53:837-841.
- Marks, C. F., Saidak, W. J., and Johnson, P. W. 1973. Effects of soil management on numbers of the root-lesion nematode *Pratylenchus penetrans* in soils of Ontario peach orchards. *Can. J. Plant Sci.* 53:181-185.
- Marriage, P. B. 1973. Herbicidal activity and metabolism of dyrene in Canada thistle. *Weed Sci.* 21:389-392.
- McKeen, C. D., and Thorpe, H. J. 1973. Pathogenic species of *Verticillium* in horticultural crops and weeds in southwestern Ontario. *Can. J. Plant Sci.* 53:615-622.
- Miller, C. D. F., and Guppy, J. C. 1972. Notes on the biology of the alfalfa weevil, *Hypera postica* (Gyllenhal) (Coleoptera: Curculionidae) in southern Ontario. *Proc. Entomol. Soc. Ont.* 102:42-46.
- Quamme, H., Weiser, C. J., and Stushnoff, C. 1973. The mechanism of freezing injury in xylem of winter apple twigs. *Plant Physiol.* 51:273-277.
- Smith, B. C., Starratt, A. N., and Bodnaryk, R. P. 1973. Oviposition responses of *Coleomegilla maculata lengi* (Coleoptera: Coccinellidae) to the wood and extracts of *Juniperus virginiana* and to various chemicals. *Ann. Entomol. Soc. Am.* 66:452-456.
- Ward, G. M. 1973. An improved technique for freeze-drying fruit samples. *Can. J. Plant Sci.* 53:603.
- Ward, G. M. 1973. Calcium deficiency symptoms in greenhouse cucumbers. *Can. J. Plant Sci.* 53:849-856.
- Ward, G. M. 1973. Causes of blossom-end rot of tomatoes based on tissue analysis. *Can. J. Plant Sci.* 53:169-174.
- Wressell, H. B. 1972. A comparison of European corn borer, *Ostrinia nubilalis* (Hubner), moth flight to light traps in southwestern Ontario and the relationship to borer infestation. *Proc. Entomol. Soc. Ont.* 102:63-71.
- Wressell, H. B. 1973. The role of parasites in the control of the European corn borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae), in southwestern Ontario. *Can. Entomol.* 105:553-557.

Miscellaneous

- Aylesworth, J. W. 1973. Breeding for quality in white beans. *Soils & Crops*, pp. 146-147.
- Bird, G. W. (Revised by Wensley, R. N.) 1973. Orchard replant problems. *Can. Dep. Agric. Publ.* 1375. 4 pp.
- Buzzell, R. I. 1973. What is acceptable stand of soybeans? *Cash Crop Farming* 34(2):33.
- Dhanvantari, B. N. 1972. Bacterial spot of peach in Ontario. *Agdex* 212/634.
- Dhanvantari, B. N. 1972. Peach canker in Ontario. *Agdex* 212/634.
- Foott, W. H. 1973. Corn aphid—insect with a big appetite. *Cornette* 10:4.

- Foott, W. H. 1973. Picnic beetles—Pests of processing-tomatoes in southwestern Ontario. *Can. Agric.* 18(2):32-33.
- Haas, J. H., and Bolwyn, B. 1973. Predicting and controlling white mold epidemics in white beans. *Can. Agric.* 18(1):28-29.
- Jaques, R. P. 1973. The persistence of viruses of *Trichoplusia ni* and *Pieris rapae* in field plots. *Proc. Vth Int. Colloq. of Insect Pathol. and Microb. Control*, Oxford, Engl., pp. 57(1), 57(2), 57(3).
- Layne, R. E. C. 1973. Peach rootstocks and winter bud hardiness of the Harrow peach series. *Md. Fruit Grower* 43:15-16.
- McClanahan, R. J. 1973. Integrated control of greenhouse pests. *Can. Agric.* 18(3):34-35.
- Miller, C. D. F. 1973. Alfalfa weevil—Blessing in disguise? *Can. Agric.* 18(1):16-17.
- Scott, W. A. 1973. Progress of the Canadian tobacco crop. *The Lighter* 43(1):10; 43(2):8; 43(3):8; 43(4):9.
- Scott, W. A., and Elliot, J. M. 1973. A survey of burley tobacco grown in Ontario in 1972. *The Lighter* 43(4):17-21.
- Ward, G. M. 1973. Leaf analysis for greenhouse vegetable crops. *Agdex* 290/532.

Research Station Ottawa, Ontario

PROFESSIONAL STAFF

F. K. KRISTJANSSON, B.S.A., M.S., Ph.D.	Director
L. H. LYALL, B.S.A., M.S.	Assistant Director
J. G. R. LOISELLE, B.Sc. (Agr.), M.Sc., Ph.D.	Plant gene resources
R. W. MARTIN	Administrative Officer

Cereal Crops Section

V. D. BURROWS, B.S.A., M.Sc., Ph.D.	Head of Section; Plant physiology, oats and barley
R. V. CLARK, B.Sc. (Agr.), M.Sc., Ph.D.	Plant pathology
I. DE LA ROCHE, B.Sc., M.Sc., Ph.D.	Quality
G. FEDAK, B.S.A., M.Sc., Ph.D.	Barley
S. O. FEJER, Ing. Agr., Dr. Sc. Tech.	Barley
J. E. FISHER, B.S.A., M.Sc., Ph.D.	Morphology
V. A. HELSON, B.A., M.A.	Environmental physiology
D. P. HOLMES, B.Sc., Ph.D.	Growth analysis
A. G. PLESSERS, B.Sc. (Agr.), M.Sc., Ph.D.	Hybrid winter wheat
D. R. SAMPSON, B.Sc., A.M., Ph.D.	Wheat
J. T. SLYKHUIS, B.Sc., M.Sc., Ph.D.	Virology
S. SYMKO, Ing. Agr.	Barley and triticale

Crop Loss Section

V. R. WALLEN, B.Sc., M.Sc., Ph.D.	Head of Section; Aerial photography, methodology
P. K. BASU, B.Sc., M.Sc., Ph.D.	Surveys and methodology
W. C. JAMES, B.Sc., Ph.D.	Surveys and methodology
W. L. SEAMAN, B.Sc., Ph.D.	Surveys and Editor, Canadian Plant Disease Survey

Cytogenetics Section

T. RAJHATHY, Ing. Agr., M.Sc., D. Agr. Sci.	Head of Section; Cereal crops
K. C. ARMSTRONG, B.S.A., Ph.D.	Forage crops

W. A. KELLER, B.S.A., Ph.D.
B. E. MURRAY (Miss), B.S.A., M.Sc., Ph.D.

Haploidy
Protein genetics

Entomology Section

D. G. HARCOURT, B.S.A., Ph.D.	Head of Section; Population dynamics
R. BOCH, Dr. Rer. Nat.	Physiology and behavior of bees
T. BURNETT, B.S.A., Ph.D.	Population ecology
T. A. GOCHNAUER, B.A., M.S., Ph.D.	Pathology of bees
J. C. GUPPY, B.S.A., M.S.	Population dynamics

Forage Crops Section

W. R. CHILDERS, B.Sc. (Agr.), M.S., Ph.D.	Head of Section; Legumes and grasses
H. BAENZIGER, Ing. Agr., M.Sc., Ph.D.	Legumes
L. M. CASSERLY, B.A., B.S.A., M.Sc.	Corn
C. C. CHI, B.Sc., M.Sc., Ph.D.	Plant pathology
L. DESSUREAUX, B.A., B.Sc., M.S., Ph.D.	Alfalfa genetics
L. S. DONOVAN, B.S.A., M.S., Ph.D.	Corn and soybeans
D. R. GIBSON, B.Sc. (Agr.)	Corn
R. W. ROBERTSON, B.S.A.	Plant introduction
H. D. VOLDENG, B.S.A., M.Sc., Ph.D.	Plant physiology
F. S. WARREN, B.S.A., M.Sc., Ph.D.	Corn

Horticultural Crops

G. R. JOHNSTON, ¹ B.S.A., M.S.A.	Potatoes
---	----------

Experimental Farm, Kapuskasing, Ont.

J. M. WAUTHY, B.Sc. (Agr.)	Superintendent; Crop management and evaluation
----------------------------	--

Experimental Farm, Smithfield, Ont.

H. B. HEENEY, B.Sc. (Agr.), M.Sc.	Superintendent; Plant nutrition and irrigation
H. L. HOUSE, B.S.A., Ph.D.	Insect physiology and nutrition
S. J. LEUTY, B.S.A., M.S., Ph.D.	Fruit crop management
S. R. MILLER, B.Sc., M.Sc., Ph.D.	Plant physiology and biochemistry
W. P. MOHR, B.S.A., M.S.A., Ph.D.	Food processing
L. G. MONTEITH, B.S.A., M.S.A.	Fruit management, pest control

Experimental Farm, Thunder Bay, Ont.

W. B. TOWILL, B.S.A.

Superintendent; Crop management
and evaluation

Departures

A. T. BOLTON, B.Sc., M.Sc., Ph.D.

Plant pathology

Transferred April 1973 to Plant Research Institute,
Ottawa (now partly Ornamentals Research
Service)

M. K. MUKERJI, B.Sc., M.Sc., Ph.D.

Population dynamics, energetics

Transferred July 1973 to Research Station,
Saskatoon, Sask.

¹Stationed at University of Guelph, Guelph, Ont.

INTRODUCTION

The program at the Research Station, Ottawa, Ont., emphasizes research on animal feed crops, including cereals, corn, and forage crops. Termination of the tomato breeding program in 1973 completed the phasing out of research on fruit and vegetable crops. Seed stocks of Ottawa tomato cultivars and potentially valuable breeding lines will still be maintained.

The plant breeding programs continued to be productive; two oat cultivars and one corn hybrid were licensed in 1973.

This report summarizes some of the more important research results from the Station in 1973. Requests for further information should be directed to: Research Station, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

F. K. Kristjansson
Director

CEREAL CROPS

Wheat

Breeding. The new soft white winter wheat Fredrick is being well received by seed growers and industry. In addition to pastry-quality wheat, increased emphasis is being placed on breeding high-yielding winter feed wheats for southern Ontario and spring feed types for areas where winter wheat does not succeed. Wheatlike derivatives from wheat \times triticale crosses provide a rich genetic base for improving the yield, winterhardiness, and virus resistance of winter wheat. Spring wheat improvement depends on the cross Opal \times Pitic 62; selection criteria include delayed double ridge formation during spikelet development, giving more kernels per spike.

Five groups of winter triticale crosses, ranging in generation from C₃ to C₁₂, are under evaluation. Excellent success has been achieved in selecting true breeding strains that are high yielding, have plump nonshriveled kernels, and are disease resistant and winter-hardy. Some of these strains cross readily with normal wheat. Work on spring triticale is less advanced.

The hybrid winter wheat program is broadly based on about 50 different strains or cultivars, and we now have over 80 male-sterile lines. Fertility restoration and cross-pollination are excellent at Ottawa. The first field trial of 19 hybrids was seeded at two locations in the fall of 1973.

Quality. Comparison of 28 quality prediction tests, using 100 cultivars, showed that 95% of the variance in bread and pastry quality was accounted for by three tests,

mixograph development time, percent protein, and kernel hardness. The kernel hardness test developed here accounted for 93% of the total variation among soft wheats. Highly significant year \times location interactions occurred for most of the 28 tests, pointing to the need for control varieties in field trials to represent different quality classes.

Winter survival. Using electron spin resonance we have demonstrated differences in the physical structure of membranes in hardened vs. nonhardened tissues. Field studies showed that plant survival is a function of a slower dehardening rate in the spring and reduced metabolism under an ice cover.

Physiology. External application of gibberellic acid (GA) on Marquis wheat accelerated the early development and elongation of the apex, hastened the formation of the apical spikelet, and increased the rate of primordium production. Chlormequat chloride (Cycocel) had little effect on apex development of Marquis. GA, applied to the cultivar Pitic 62, accentuated the Norin 10 type of apex development pattern. GA-treated plants had longer apices with more "stacked" single ridges before spikelet development than untreated plants. Plants treated with chlormequat chloride showed the reverse effect, with fewer "stacked" single ridges.

Developmental morphology. Morphological evidence of a latent floret primordium in the axil of the second sterile glume of the lateral spikelets of diploid, tetraploid, and hexaploid wheat, and of rye, has been found. The primordium may be a relict of a previously

existing floret in a primitive ancestor of the Triticinae. Potentially, this inhibited primordium represents an extra grain in each spikelet of the head—if it could be induced to develop.

Virology. Improved procedures for root-to-root transmission of wheat spindle streak mosaic virus, in the absence of infectious soil, show promise as an aid in determining how the virus is carried in nature. In a yield test in which soil from an infected field was placed beneath the seedbed before the plots were seeded in the fall, Talbot suffered 51.6% yield reduction and Genesee, 43.2%. Severe development of spindle streak mosaic in 1973 enabled the selection of many triticale lines that appeared to be immune, like the rye parents.

Oats

Breeding. Cultivars Gemini (OA123-1) and Hinoat (OA123-3-3) were licensed in 1973, and seed was distributed to seed growers. Both cultivars are of interspecific origin being derived from crosses of *Avena sativa* × *A. strigosa*². Gemini is a high-yielding seed oat adapted across Canada. Hinoat is a high-protein type and is the first Canadian oat cultivar bred for the food-processing industry. Its yield per hectare is approximately 25% less than that of the recommended feed-type cultivars, but its seed contains approximately 25% more protein. A food manufacturer arranged production of the variety under contract in Saskatchewan in 1973, and paid a premium to growers to offset the lower yield potential.

Physiology. A growth-chamber screening procedure for identifying single plants with high seed yield and high seed-protein potential has been tested, using the seed yields from Eastern Cooperative Oat Tests from 1968 to 1972 inclusive. Fresh and dry weights of 4-wk-old oat shoots grown in growth chambers indicated the discarding of 67% of the cultivars that were actually discarded by the Eastern Cooperative Oat Tests. Because seed yield in the plots is not the only criterion used for discarding cultivars in the breeding program, this rapid, growth-chamber screening procedure may have merit as a means of reducing the number of cultivars grown in plots at the different stations.

A series of experiments was carried out to study the effects of various growth regulators

and amino acids on comparative rates of senescence of excised leaf sections from oat lines differing in grain protein content. Senescence of the sections was delayed differentially by kinetin solution over a concentration range of 1 to 5 ppm. Treated leaf sections from the three high-protein lines senesced more slowly than those from the three low-protein lines. Thus, at 4 to 5 days after excision the former sections appeared ± green, whereas the latter appeared ± yellow. This work demonstrated the feasibility of a rapid screening test for protein content of the grain by using excised leaf sections.

Diseases. Seed yields of oats were increased by 68 to 100% when plots were sprayed with the fungicide maneb. At maturity, the sprayed crops were erect, had good color, and were practically disease-free. In contrast the straw of the unsprayed plots was black in color and severely lodged.

Tolerance for crown and stem rust was again observed to be greater in dormoats sown in fall than in those sown in spring. The tissues of fall-sown dormoat plants are apparently modified by early-spring growing conditions, causing them to be more tolerant of diseases.

Barley

Breeding. The barley strain OB95-21 was licensed under the name Vanier and released to growers of pedigreed seed. Vanier is resistant to loose smut and stem rust and has field tolerance for prevalent races of powdery mildew. It is similar in height to Champlain, but is higher yielding and more resistant to lodging. Vanier is well adapted to growing conditions in eastern Ontario, and may serve as a replacement for Champlain in this area.

Sixty homozygous lines were produced by doubling haploids obtained from *Hordeum vulgare* × *H. bulbosum* crosses and enough seed was obtained for field plot testing in 1974.

Interspecific barley breeding. Intercrosses of *H. bulbosum* and *H. murinum* with *H. vulgare* have created unique new gene pools for barley improvement. Different strains of *H. bulbosum* were intercrossed before crossing with *H. vulgare*. A number of tetraploid strains have shown good fertility combined with good winterhardiness and lodging resistance.

Genetics. Strains with pubescent leaves and sheaths were isolated from *H. spontaneum* collections and from *H. vulgare* × *H. bulbosum* hybrids. Pubescence in each structure is controlled by single dominant genes inherited independently. Genes from the two strains appear to be identical. Pubescent leaves offer the potential for resistance to the cereal leaf beetle.

Quantitative genetics. Levels of heterosis were studied in progenies of various winter × spring barley hybrids. Levels of heterosis for grain yield relative to the spring parent decreased from 62% under spaced planting to 22% under solid seeding, due to restriction of head number under higher plant competition. In a factorial experiment composed of conventional varieties and short-strawed introductions, heterosis for grain yield was reduced from 48% in spaced-planted F_1 to 11% in solid-seeded F_2 .

Quality. In cooperation with Dr. A. R. Mack, Soil Research Institute, proximate fractions were examined of Brock and Fergus barley planted at four dates spaced at weekly intervals, each under three moisture levels of 25, 50, and 90% field capacity. The later planting dates caused significant increases in protein content of both varieties. In addition the ash content of Fergus and the fat and fiber content of Brock were increased by delayed planting. These results will have important implications if studies are initiated to determine genetic differences in feeding quality between strains of barley.

CROP LOSS ASSESSMENT

Methodology

Tomatoes. Field-plot experiments with nine tomato cultivars (John Baer, Fireball VR, New Yorker, Mini-Rose, Trent, Ottawa 78, Heinz 1350, Campbell 19, and Jet Star) at Ottawa showed that the progress of early blight, caused by *Alternaria porri* f. sp. *solani* (Ell.) Ciferri, could be determined by counting the dead leaves and infected fruits; that yields were not significantly reduced until defoliation exceeded 60%; and that the fruit losses of moderately and severely infected plants were 4–13% and 13–37% respectively. The cultivar Mini-Rose suffered no loss from the disease. It was also found that 75% of the primary infection was controlled by soil

fumigation with Vorlex (Nor-Am Horticultural Products Ltd.) at the rate of 560 litres/ha (50 gal/ac).

Peas. By using a uniform method of survey, common root rot, caused by *Fusarium* spp., was found to be the most prevalent disease of processing peas in Canada. It was shown that yield loss due to *Fusarium* spp. could be estimated from the percentage of most severely affected plants.

Alfalfa. A stem-smear technique was developed to identify bacterial wilt, *Corynebacterium insidiosum* (McCull.) Jensen, of alfalfa, irrespective of variable external disease symptoms. A simplified method of estimating the incidence of alfalfa foliage diseases in farmers' fields has been developed.

Potatoes. Plots in an experiment represent a farmer's field only when the treatments do not interfere with each other. When late blight of potato was allowed to develop in one treatment in a field experiment, interplot interference was confirmed. In trials designed to screen cultivars for resistance to late blight, this could lead to unjustified rejection of a cultivar or underestimation of cultivar performance.

A computer program (PHYTOSIM) has been built that simulates the development of late blight of potato, and is currently being incorporated in a disease management scheme that maximizes potato production and decreases fungicide usage to a minimum level commensurate with rational disease control.

Remote sensing. An automatic computer analysis technique to determine levels of aphid infestation in cornfields was developed, by using photographic color separation and image enhancement procedures from infrared aerochrome photographs. Panels of healthy and infested cornfields were selected for enhancement whereby density ranges of the cyan layer were compressed to a high-contrast mode. Finally the panels were scanned and the information recorded on magnetic tape and analyzed by computer.

In 1972, 65 beanfields totaling 614 ha (1,519 ac) were aerially photographed in the vicinity of Hensall, Ont. Fifty-one of the 65 fields were infected with bacterial blight. Although most fields had less than 1% infection, levels ranged up to 6%. The overall infection was low, 0.668% or 4.04 ha (10 ac) of the total bean acreage under the flight

path. This level of infection is the lowest since the aerial photography program was started in 1968.

Surveys

Missing plants. Experimental results were used to interpret survey data, which showed that the average Netted Gem crop in New Brunswick in 1972 had only 75% of the normal stand. The yield loss due to missing plants at emergence in New Brunswick in 1972 was equivalent to a financial loss of approximately \$1½ million.

Potato late blight. Despite the fact that potato late blight was not prevalent in 1972, every farmer in Prince Edward Island used fungicides. They applied an average of 5.4 sprays, using over 72.57 t (80 tons) of fungicide to protect 12,950 ha (32,000 ac) at an estimated total cost of half a million dollars. Mancozeb was the fungicide most commonly used, followed by maneb and metiram.

Ergot. Cooperative field surveys in the Prairie Provinces indicated that ergot was less prevalent than in 1972 in most of the wheat-growing areas where it has been a problem in recent years. Roadside grasses not cut before heading continue to serve as a reservoir of inoculum from year to year.

Barley diseases. A survey of 35 fields in 10 counties of western Ontario in July 1973 showed that spot blotch, caused by the fungus *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem., was the most prevalent and serious disease. This organism is also the primary cause of root rot of barley.

New disease problems. The unrestricted importation of large quantities of seed of fababeans, *Vicia faba* var. *minor*, from Europe has resulted in the appearance of several potentially serious pathogens in many areas of Canada. These include *Botrytis fabae*, *Ascochyta fabae* Speg., bean yellow mosaic, and *Uromyces viciae-fabae*.

CYTOGENETICS

Oats

Cytogenetic architecture. Living specimens of *Avena macrostachya* Bal. were studied for the first time. This species was found to have three characters unique in the genus: (i) perennial growth habit, (ii) allogamy, and

(iii) autotetraploidy. Clones were established, but due to very irregular heading no seed was obtained. The plants have not responded to vernalization or to photoperiodic treatments. A mean chromosome pairing of 0.13I 6.06II 3.93IV was typical for an autotetraploid.

Aneuploidy. The seven primary trisomics of *A. strigosa* Schreb. were identified by karyotype analysis and phenotypic differences and the segregating desynaptic gene (*ds ds*) was removed by selection. This set is now available for gene dosage studies and for associating markers and agronomically useful genes with their linkage groups. The series of 21 monosomics of *A. sativa* L. has been completed. Because these lines originated from six different genotypes, they are being backcrossed into the cultivar Sun II. The use of the cultivar Kanota as a recurrent parent was discontinued because the Kanota monosomics, with the exception of one line, were poor yielders of nullisomics. The marked effect of the genotype on the male transmission of monosomes is being investigated.

Electrophoretic studies in Avena. Electrophoretic patterns of natural populations of *Avena* species indicate that selection processes differentiate patterns with wide and with narrow geographic distribution. The diploid *A. canariensis* Baum, Rajhathy & Sampson, from an island habitat, was polymorphic for both electrophoretic patterns and morphological characters; associations were found between specific allozymes and some morphological characters and elevation gradients. Clinal patterns and narrow distribution were characteristics of the polymorphic *A. longiglumis* Dur. and of *A. hirtula* Lag., populations from the Mediterranean region, and of *A. barbata* Pott, from the Middle East. However, a Mediterranean *A. barbata* and a western Mediterranean *A. hirtula* type, with wide adaptation, were identified. Natural populations of *A. sterilis* L. from Iran were polymorphic with the exception of a specific zymotype that was associated with a particular soil-climate environment.

The esterase zymotype *A. canariensis* was distinctive from that of the A and C genome diploids and had allozymes in common with tetraploid and hexaploid species, providing evidence of a progenitor role for *A. canariensis*.

Bromegrass

Chromosome pairing in an F_1 hybrid (*Bromus erectus* Huds. \times *B. pumpellianus* Scribn. ssp. *dicksonii* Mitchell & Wilton), genome AAAB, was complete indicating that the A and B genomes are nearly homologous. However, evidence was found of several gross structural differences. In an F_1 hybrid, genome AAABBB (*B. pumpellianus* ssp. *dicksonii* \times *B. pumpellianus* Scribn.), there was evidence of chromosome pairing between the A and B genomes, but the tendency was toward preferential pairing, indicating differentiation between the A and B genomes. These results support the conclusion that bivalent pairing in *B. pumpellianus* ssp. *dicksonii* (AABB) is a result of preferential pairing, but that occasional pairing could occur between the A and B genomes as a result of homology. Chromosome pairing in an F_1 hybrid from *B. erectus* \times *B. pumpellianus* was the same as that observed in *B. erectus* \times *B. inermis* Leyss. implying that the genome formulas of the hybrid and *B. pumpellianus* were AAAABB and AAAABBBB respectively.

ENTOMOLOGY

Insect Population Dynamics

Alfalfa weevil. Populations of the alfalfa weevil, *Hypera postica* (Gyll.), increased to epidemic levels throughout south-central Ontario in 1973. Numbers of eggs in study plots in Hastings and Northumberland counties reached 8,600/m² (800/ft²), but populations were annihilated in early June from an epizootic caused by a fungus new to the insect in North America. Larval mortalities ranged from 80 to 94% and loss of larvae and pupae in cocoons, from 43 to 54%.

A biometrically orientated sampling system has been developed for recording numbers of eggs in the spring growth of alfalfa. It comprises two methods: the first is based on direct counts of the eggs, which are laid in clusters and hence are overdispersed in distribution. For typical levels of infestation, estimates with acceptable precision and probability may be obtained by taking a single three-stem bouquet of alfalfa from 80 randomly selected 0.09-m² (1-ft²) quadrats within a field. However, the sampling requirement increases sharply at low densities. The second method consists of counting the

oviposition punctures, which are randomly distributed. The counts provide a valid index of the number of eggs until late in the hatching period. This second method is slightly less accurate but requires a single bouquet from just 32 quadrats.

Seasonal development of field populations of the weevil may now be predicted. A mathematical model, derived from time-temperature data obtained under controlled conditions, is used to calculate trends in development using mean daily temperature values. It also permits calculation of thermal requirements in terms of degree-days within a specified temperature range. Accumulated degree-days (base 10°C) during development of the weevil at two Ontario locations did not differ significantly from thermal requirements calculated.

Two-spotted mite. As part of a statistical technique for predicting the degree of predation by *Amblyseius fallacis* (Gar.) needed to control *Tetranychus urticae* Koch, the two-spotted mite, a mathematical model was developed to measure dispersal of the predator in relation to that of the prey. The model has been programmed for testing with field and greenhouse data.

To provide the additional predation estimated by the model, two methods were developed for producing small, self-sustaining colonies of *A. fallacis*. Initially, the predator was reared on fresh pollen of the white hyacinth and of gladiolus. Then, a food chain was constructed consisting of a chemically defined diet, the mold *Trichoderma* sp. growing on the diet, a tarsonemid mite feeding on the mold, and *A. fallacis* predating the tarsonemid mite. However, both methods proved to be too costly and labor-intensive for field use. A large number of less expensive substitutes for the chemically defined diet have been tested as a basis for the food chain; the predator developed from egg to adult and mated, but produced few eggs.

Honey Bees

Behavior. Worker bees of a line recognized for its aggressive behavior were found to be more alert to disturbances by intruders, and much more responsive to the alarm substance, than bees of a gentle line. The former contained about 33% more isopentyl acetate in their sting apparatus than the latter. The

behavior of F₁ hybrids suggested that gentleness is dominant; however, production of the alarm pheromone resembled that of the aggressive parent with indications of heterosis.

When given a choice, worker bees preferred their own queen and rejected a strange queen. The mechanism by which they can differentiate between their own and a similar strange queen was found to be based on the recognition of hive odors which the queen has absorbed and which are peculiar to her hive. To distinguish accurately between two queens, a worker must have direct antennal and proboscis contact.

Nutrition. Ethylene oxide fumigation reduced the content of histidine in stored dandelion pollen and of histidine and methionine in rape pollen. It also destroyed a number of unidentified lipid attractants. As a result, foraging bees collected less pollen, and bees in the hive consumed less and reared fewer larvae.

Diseases. Strains of *Bacillus larvae* White, the causal organism of American foulbrood, varied in their capacity to produce spores and proteases in aerated broth culture. However, the addition of activated charcoal to the medium increased both products. The small-molecular-size protease appeared first; optimal sporulation was accompanied by release of the large-molecular-size enzyme. Continued incubation usually resulted in reduction of free spores and the disappearance of proteases.

FORAGE CROPS

Grasses

Orchardgrass. Seed yields of individual plants of the progenies of Kay orchardgrass clones indicate considerable opportunity for selection for seed yield in this cultivar. Evidence from the Grassland Experimental Station at Teulon, Man., indicates that the new cultivar Juno is winter-hardy and yields well under beef pasture management.

Timothy. An application has been submitted to license the experimental strain S₃-9 under the cultivar name Basho. It is a pasture type, taller and slightly higher yielding than Champ, with a greater seed-yielding potential. Leaf-area studies on improved parental plants of the experimental strain Labelle

indicate great differences in leaf area, a feature that may influence forage and seed yields.

Bromegrass. The high-seed-yielding synthetic D-9 showed considerable promise in a forage yield trial at nine stations in Eastern Canada. The Breeder seed field yielded 518 kg of cleaned seed per ha (462 lb/ac), almost twice the yield of Saratoga, Baylor, and Redpatch. In 1974, data will be available for assessment and possible licensing.

Alfalfa

New cultivars. Seed multiplication of the two new varieties, Angus and Algonquin, is progressing under the Canadian Forage Seed Project. Foundation plantings established in 1973 were 29.3 ha (72.5 ac) for Angus and 26.3 ha (65 ac) for Algonquin, most of which are located in the Prairie Provinces. In addition, crops were established for producing Certified seed of both varieties, and seed for forage production will be available in the spring of 1975.

In 12 station-years of forage trials in Ontario, Angus outyielded Saranac 6,949 kg/ha (6,199 lb/ac) to 6,753 kg/ha (6,024 lb/ac), and Algonquin at 6,919 kg/ha (6,172 lb/ac) compared favorably with Vernal at 6,695 kg/ha (5,972 lb/ac).

Breeding methods. Progress was made in combining two synthetics so as to maximize selection for both heterozygosity and more favorable alleles for vigor. Seed of a new synthetic, BBWW1, has been increased for establishment of extensive trials in 1974.

Corn

Breeding. With the steady expansion of grain corn production in eastern Ontario and southern Quebec, increasing attention is being paid to development of greater resistance to stalk rot and the European corn borer. Sources of good stalk quality used to date include corn belt hybrids and stiff-stalk synthetics. Programs are under way to develop lines from backcross progenies, using adapted early-maturing lines as recurrent parents, and from the earliest segregates in the synthetics. We have been able to produce only a few of the latter at Ottawa. In contrast, the synthetics resistant to the corn borer have provided several early segregates.

In off-station testing, response of the experimental hybrid OX450 was quite variable from one area to others with approximately the same heat unit accumulation. In southern Manitoba, stalk rot was extensive, whereas in southern Alberta it was essentially absent. The Alberta tests were grown under irrigation, minimizing the drought stresses that predispose corn to stalk rot. Also, light autumn rainfall ensured against high soil moisture as the crop matured. High soil moisture near the end of the season favors the development of stalk rot.

Growth and development. The response of corn to stress imposed by interplant competition was studied by varying row width, distance between plants within the row, and the number of plants per hill. Plant arrangement had only a small effect on the yield of grain; the area of land per plant was the critical factor.

Leaf area, rate of dry matter production, and dry matter yield at maturity of a tillered and a single-stalk hybrid were compared at plant populations of 20,400, 40,000, and 112,000 plants/ha (8,260, 16,200, and 45,000 plants/ac). The greatest differences were in leaf area. At the lowest density, the tillered hybrid had over twice the leaf area of the single-stalk hybrid.

Agronomic practices. Grain loss in eight recommended corn hybrids during harvesting was measured over a 3-yr period with four successive harvests each year. Total grain loss per year averaged about 5%. Losses were higher for the earlier harvests, when grain moisture levels were over 28%, and increased again for the later harvests as moisture decreased below 25%. Most of the loss was attributable to machine deficiencies. Hybrid performance was highly consistent; certain hybrids had relatively low losses for each harvest every year.

Over a 3-yr period on Grenville sandy loam, herbicides, cultivation, and added N each contributed to increased corn-silage yield. Grain yield response was similar but more variable. Increases due to cultivation and herbicides were largest at the lower N levels. Each of the herbicides accounted for large increases in corn yield, but differences between herbicides were small. A combination of adequate N fertilization, effective herbicide application, and one timely cultivation gave the most efficient production.

When butylate (Sutan; Stauffer Chemical Co.) was used for control of annual weeds in corn, incorporation into the soil immediately after spraying gave the best results. At Ottawa, butylate application increased yields of silage and grain, and these were further increased if butylate was incorporated after application. However, delays of up to 2 h in 1972, and 24 h in 1973 had no effect on weed control or corn production.

Soybeans

Breeding. In a program to develop high-oil and high-protein strains adapted to areas having less than 2,700 heat units, 16 high-oil strains produced an averaged yield of 3,725 kg/ha (55.5 bu/ac) and 12 high-protein strains averaged 2,475 kg/ha (36.9 bu/ac). This one-third reduction in yield by the high-protein strains in a favorable growing season illustrates the main obstacle in breeding competitive varieties. The higher protein content of the beans does not yet compensate for the lower yield.

Two high-protein lines were grown in growth chambers at 17.5 and 22.5°C until the beginning of pod development, and afterward at temperatures of 17.5, 22.5, and 27.5°C. The higher vegetative temperature in all cases resulted in greater seed production. One genotype had an optimal reproductive temperature 5°C below that of the other. Increasing the vegetative temperature had only small effects on N and oil content and fatty acid composition. In contrast, increasing the reproductive temperature by 10°C halved the content of linolenic acid.

Pathology

Toxins of Bipolaris sorokiniana. The relation between seedling survival of *Triticum* varieties or lines and reaction to toxic metabolites of *B. sorokiniana* (Sacc. in Sorok.) Shoem. has been developed. There was little relation between the speed of germination and survival of seedlings after inoculation with *B. sorokiniana*. The great sensitivity of wheat to culture filtrates showed that toxic metabolites may play a part in the infection process at a later stage of growth. Under natural conditions, there was little relation between the aggressiveness of different isolates of *B. sorokiniana* toward wheat seedlings and toxicity of culture filtrates. The differential germination and growth responses of host varieties to culture filtrates

show that more than one factor may be involved or else that the toxin has greater specificity than has been thought.

Preliminary studies on the compatibility reaction of ascospore isolates demonstrated that some were cross-fertile with one or the other of the parental isolates, whereas others did not mate with other parents.

Introductions

Many introductions showed promise: alfalfa, *Medicago sativa* L., from Poland and USSR outyielded the controls (Iroquois and Saranac) in forage production; crownvetch, *Coronilla varia* L., from Austria compared favorably in forage yield with the above alfalfa checks; cicer milkvetch, *Astragalus cicer* L., a new improved strain yielded 336.3 kg/ha (300 lb/ac) of Breeder seed; Hungarian clover, *Trifolium pannonicum* Jacq., from Romania equaled red clover in forage production and had greater persistence and tolerance for flooding; brome grass, *Bromus inermis* Leyss., from Romania and the USSR outyielded Redpatch in forage production; orchardgrass, *Dactylis glomerata* L., a hardy strain from the USSR and an early-maturing strain from Czechoslovakia, gave higher forage production than Rideau; and timothy, *Phleum pratense* L., from Czechoslovakia gave a higher forage yield than Champ.

HORTICULTURAL CROPS

Potatoes

Breeding and testing. Fredericton-bred F61025 can be recommended for release to growers when sufficient seed is multiplied. It is main-crop in vine maturity, but the tubers size early. It is resistant to verticillium wilt, is a good yielder, and is excellent for table use and for chipping. Abnaki, a high-yielding, main-crop, multiple disease-resistant table-stock variety, developed by the USDA, was licensed in 1973. Hudson (NY 41) continued to be a top yielder, but the culinary quality is mediocre. Both Fredericton-bred F58010 and Guelph-bred G6880-1 produced tubers of excellent table and processing quality, but the 1973 yields were disappointing.

EXPERIMENTAL FARM, KAPUSKASING, ONT.

Special Crops

Fababean management and adaptation. Fababeans were evaluated under various management methods. Early seeding greatly increased grain yields: 800 kg/ha (714 lb/ac) from seeding on June 14, 4,019 kg/ha (3,585 lb/ac) from May 22, and 4,829 kg/ha (4,307 lb/ac) from April 26. A higher seeding rate significantly increased grain production. Increasing the N fertilization resulted in slightly lower grain yields, but there were significant increases from application of P at rates up to 30 kg/ha (26.8 lb/ac). A N \times P interaction indicated that a higher level of P was required at a lower level of N. The earliest variety, Hertz Freya, outyielded Ostlers by 548 kg/ha (489 lb/ac) and Ackerperle by 1,217 kg/ha (1,086 lb/ac).

When the same management practices were applied to silage production, the April and May seedings significantly outyielded the June seeding. There was a highly significant increase in silage yield when the seeding rate was increased from 250,000 to 375,000 plants/ha (101,250 to 151,875 plants/ac). Silage yield showed little effect from changes in N and P levels, although there was a slight increase when P was added at 30 kg/ha. Ostlers outyielded Hertz Freya by 1,362 kg/ha (1,215 lb/ac) and Ackerperle by 1,854 kg/ha (1,654 lb/ac) in silage production.

Fababeans seem to have a limited potential as a grain crop in our area because of their ripening period and habit. However, they may be of some use as a silage crop.

EXPERIMENTAL FARM, SMITHFIELD, ONT.

Vegetables

Relation of pea tenderometer readings to yield and seasonal rainfall. In the period 1963-70 the correlation coefficients between tenderometer reading and yield of shelled fresh peas of the cultivar Pride averaged +0.751 and the regression coefficients averaged +0.811. In 1973 the correlation coefficients ranged from +0.792 to +0.923 for nine varieties and the regression coefficients averaged +0.815. In long-term studies on canning peas, yields can be corrected to a tenderometer reading of 105 and a seasonal

rainfall of 6.5 in. by the following equation: $\text{Log Corrected Yield (cwt/ac)} = \text{Log Actual Y} + \text{Log (105 - 50)} - \text{Log (Actual Tenderometer - 50)}0.811 + (0.300 - b)$, where $b = 0.1076 (\text{in. rainfall}) - 0.406$.

Color studies in high-color tomato lines. Tomato fruits with the gene for either high pigment (*hp*) or crimson (*og^C*), or both, have higher flesh color than normal lines. Canning altered color, but differences that existed before processing remained after canning and storage. Fresh samples can be used to indicate the color differences expected after canning and storage. Unlike normal types, *hp* and *og^C* lines processed slightly immature were not downgraded for juice quality. Lycopene and β -carotene were distinguished structurally within the cell by electron microscopy, but high-color and normal lines could not be differentiated on the basis of subcellular structures. Biochemical analyses indicated the principal difference is the relative levels of the two pigments.

Fruits

Relation of potassium and zinc levels to strawberry winter survival. Potash applied to Redcoat strawberries in the spring increased the level of foliar K from 1.1 to 1.3% on a dry-weight basis (DWB) in October. ZnSO_4 applied as a 0.15% foliar spray increased the level of Zn in the foliage in October from 20 to 25 ppm, DWB. Higher K and Zn were correlated with increased runner production, winter survival index, and yield, in both parent and daughter plants. Optimum K and Zn levels in the foliage in October should be 1.30% and 25 ppm respectively.

Influence of Dikar on magnesium levels in apple tissues. With regular use of Dikar (Rohm & Haas Inc.) to control apple scab the several kilograms of Mn accumulated per hectare could result in toxicity. Mn levels in washed leaves from trees treated with Dikar for three seasons were four times greater than levels in leaves from dodine-treated trees. After 3 yr of application, Mn levels were doubled in Dikar-treated leaves and were increased by $2\frac{1}{2}$ to 4 times in fruit spurs. These results suggest that Dikar should not be used in orchards with Mn levels in the high adequate range.

Prediction of apple tree vigor. After 4 yr of growth, the percentage of bark in the roots of

the Ottawa clonal rootstocks was not correlated with tree height ($r = -.2540$). Height of 4-yr grafted trees was related to dry weight of leaf samples from ungrafted rootstocks grown either in stoolbeds ($r = -.867^{**}$) or as free-standing nursery trees ($r = -.751^{**}$). Leaf dry weight may serve as a useful selection tool for predicting dwarfing potential of apple rootstocks.

Control of growth and fruitfulness of young Spy apple cultivar on M 26 rootstock. Spring applications of SADH (Alar B-9; UniRoyal Co.) reduced tree size by 16, 22, and 56% respectively when applied during one, two, or three successive seasons. Reduction in tree size was associated with increased flower-bud formation and control of the amount of barren wood caused by blind buds. Increased fruit yield brought about by SADH treatment was greater than would be predicted on the basis of flower counts.

Influence of rootstock progenies on precocity of apple cultivars. There was no difference in precocity, as measured by total productivity, of Quinte after 4 yr on seedling rootstocks from crosses between Ottawa clonal rootstocks 1, 4, 5, 7, 8, and 13. McIntosh was most productive on progenies involving the clonal rootstock Ottawa 13 as a parent, suggesting a potential genetic source of precocity. Productivity of Ottawa hybrid rootstocks OH-1 and OH-3 included in this test ranked among the lowest when McIntosh was the indicator.

New clonal apple rootstock. Seven years of results from Ottawa and Smithfield show that McIntosh and Quinte, grown on the winter-hardy clone Ottawa 3, are equivalent in size, vigor, productivity, and production efficiency to their counterparts on the less hardy M 26 roots. Ottawa 3 is to be released in early 1974 by the research establishments at Ottawa, Smithfield, and St. Jean.

Artificial propagation of parasites. A means of preserving asepsis in the artificial "host" was developed, factors conducive to oviposition and egg eclosion were determined, and an improved food medium was designed. Through these innovations, together with a recently developed means of providing suitable ventilation of the "host," we have almost succeeded in the propagation of an endoparasitic Hymenoptera without resort to an insect host.

EXPERIMENTAL FARM, THUNDER BAY, ONT.

Forage Management

Effect of nitrogen, choice of species, and time of harvest on grass yields. In a comparison of six rates of N: 0, 44.8, 89.6, 132.9, 179.3, and 201.7 kg/ha (0, 40, 80, 120, 160, and 180 lb/ac) broadcast on the sod in the early spring, dry matter production of reed canarygrass, brome grass, and timothy was significantly increased with each increment. Species differed in their response to N; brome grass and reed canarygrass were superior to timothy in yield of dry matter at the higher rates. Over the past 3 yr, maximum production of timothy was obtained when N was applied at 89.4 kg/ha (80 lb/ac), but for reed canarygrass and brome grass, 179.3 kg/ha (160 lb/ac) were required. Grasses differed significantly in dry matter production at any one harvest date, due to differences in growth rates between species. In 1973, timothy reached maximum dry matter production on July 8, brome grass on July 20, and reed canarygrass on July 30.

Fertilization of grasses with N increased the crude protein in all species, with brome grass and reed canarygrass averaging 5% higher than timothy, for all treatments harvested at the late-jointing to early-boot stage of plant development.

Response of Vernal alfalfa to boron fertilization. Spring applications of B at 0, 0.56, 1.12, and 2.24 kg/ha (0, 0.5, 1, and 2 lb/ac), in combination with K at 125.6 kg/ha (100 lb/ac), have not increased yields of alfalfa grown in sandy loam soils, even though symptoms of B deficiency were identified in leaf samples taken at the late-bud stage of plant development. Visible deficiency symptoms were observed after periods of prolonged soil moisture stress.

Cereals for silage. Oat lines 1863-515 and OA123-81 have demonstrated excellent potential, both yielding an average of 17.2% more forage than the cultivar Fraser. Forage yield of Glenlea wheat was equal to the high-yielding oat lines and superior to the feed wheat Pitic 62.

Special Field Crops

Fababeans. Initial evaluation of nine varieties clearly showed that the productivity of this species may be seriously affected by chocolate spot and ascochyta leaf spot diseases, which thrive well in areas having a cool, moist growing season. In 1973, all varieties were equal in productivity, averaging 1,933.4 kg/ha (1,725 lb/ac) in yield and 82.5 kg/hl (66.3 lb/bu) in weight. Average moisture content of the seed at time of harvest on September 28 was 38.6%, necessitating auxiliary drying for safe storage.

PUBLICATIONS

Research

Armstrong, K. C. 1972. The significance of meiotic chromosome pairing in tetraploid ($2n = 28$) *Bromus pumellianus* Scribn. ssp. *dicksonii*. Can. J. Genet. & Cytol. 14:763-771.

Armstrong, K. C. 1973. Chromosome pairing in hexaploid hybrids from *Bromus erectus* ($2n = 28$) \times *B. inermis* ($2n = 56$). Can. J. Genet. & Cytol. 15:427-436.

Basu, P. K., Crête, R., Donaldson, A. G., Gourley, C. O., Haas, J. H., Harper, F. R., Lawrence, C. H., Seaman, W. L., Toms, H. N. W., Wong, S. I., and Zimmer, R. C. 1973. Prevalence and severity of disease of processing peas in Canada, 1970-71. Can. Plant Dis. Surv. 53:49-57.

Baum, B. R., Rajhathy, T., and Sampson, D. R. 1973. An important new diploid *Avena* species discovered on the Canary Islands. Can. J. Bot. 51:759-762.

Boch, R., Shearer, D. A., and Shimanuki, H. 1973. Effect of ethylene oxide fumigation on amino acid composition of pollen. Environ. Entomol. 2:937-938.

Bolton, J. L., Goplen, B. P., and Baenziger, H. 1973. World distribution and historical developments. Alfalfa Sci. Technol., Monogr. 15:1-34.

Buckley, D. J., Reid, W. S., and Voldeng, H. D. 1973. A digital leaf area measuring system using a television-scanned conveyor. Eng. Res. Serv. Paper No. 73-324.

Childers, W. R., and Grant, E. A. 1973. Bounty timothy. Can. J. Plant Sci. 53:131-133.

- Clark, R. V., and Johnston, H. W. 1973. Tolerance of oats to the septoria disease. *Can. J. Plant Sci.* 53:471-475.
- de la Roche, I. A., Andrews, C. J., and Kates, M. 1973. Changes in phospholipid composition of a winter wheat cultivar during germination at 2°C and 24°C. *Plant Physiol.* 51:468-473.
- Fedak, G. 1973. Increased chiasma frequency in desynaptic barley in response to phosphate treatments. *Can. J. Genet. & Cytol.* 15:647-649.
- Fedak, G., and Loiselle, R. 1973. Vanier barley. *Can. J. Plant Sci.* 53:495-496.
- Fejer, S. O. 1973. Genotype \times year interactions and ecovalence in raspberry selection. *Can. J. Genet. & Cytol.* 15:226-229.
- Fejer, S. O., Johnston, F. B., and Hammill, M. M. 1973. The inheritance of ascorbic acid in red raspberry. *Can. J. Genet. & Cytol.* 15:372-375.
- Fejer, S. O., and Spangelo, L. P. S. 1973. Red raspberry yield components and their relation to mechanical harvesting. *J. Am. Soc. Hortic. Sci.* 98:432-436.
- Fisher, J. E. 1973. Developmental morphology of the inflorescence in hexaploid wheat cultivars with and without the cultivar Norin 10 in their ancestry. *Can. J. Plant Sci.* 53:7-15.
- Fisher, J. E., and Symko, S. 1973. Tetralogical stamens in the flowers of triticales. *Can. J. Plant Sci.* 53:61-63.
- Fowler, D. B., Siminovitch, D., and Pomeroy, M. K. 1973. Evaluation of an artificial test for frost hardiness in wheat. *Can. J. Plant Sci.* 53:53-59.
- Gochnauer, T. A. 1973. Growth, protease formation, and sporulation of *Bacillus larvae* in aerated broth culture. *J. Invertebr. Pathol.* 22:251-257.
- Guppy, J. C., and Harcourt, D. G. 1973. A sampling plan for studies on the population dynamics of white grubs, *Phyllophaga* spp. (Coleoptera: Scarabaeidae). *Can. Entomol.* 105:479-483.
- Harcourt, D. G. 1973. *Agromyza frontella* (Rond.) (Diptera: Agromyzidae): A pest of alfalfa new to Canada. *Ann. Entomol. Soc. Que.* 18:49-51.
- Holmes, D. P. 1973. Inflorescence development of semidwarf and standard height wheat cultivars in different photoperiod and nitrogen treatments. *Can. J. Bot.* 51:941-956.
- Holmes, D. P. 1973. Effects of defoliation on chlorophyll loss in senescing wheat inflorescences and on grain maturation. *Can. J. Plant Sci.* 53:499-500.
- James, W. C., and Shih, C. S. 1973. Size and shape of plots for estimating yield losses from cereal foliage diseases. *Exp. Agric.* 9:63-71.
- James, W. C., and Shih, C. S. 1973. Relationship between incidence and severity of powdery mildew and leaf rust on winter wheat. *Phytopathology* 63:183-187.
- James, W. C., Shih, C. S., Callbeck, L. C., and Hodgson, W. A. 1973. Interplot interference in field experiments with late blight of potato (*Phytophthora infestans*). *Phytopathology* 63:1269-1275.
- James, W. C., Shih, C. S., Hodgson, W. A., and Callbeck, L. C. 1973. A method for estimating the decrease in marketable tubers caused by potato late blight. *Am. Potato J.* 50:19-23.
- Latheef, M. A., and Harcourt, D. G. 1973. A sampling plan for studies on the population dynamics of *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae) on tomato. *Entomol. Exp. & Appl.* 16:365-372.
- Leuty, S. J. 1973. Identification of maximum sensitivity of developing apple fruits to naphthaleneacetic acid. *J. Am. Soc. Hortic. Sci.* 98:247-252.
- Lister, E. E., Fisher, L. J., Jordan, W. A., Wauthy, J. M., Comeau, J. E., and Proulx, J. 1973. Influence of shelter, level of feeding, and method of forage conservation on packed cell volume and plasma metabolite levels in pregnant beef cows. *Can. J. Anim. Sci.* 53:81-88.
- Lougheed, E. C., Franklin, E. W., Miller, S. R., and Proctor, J. T. A. 1973. Firmness of McIntosh apples as affected by alar and ethylene removal from the storage atmosphere. *Can. J. Plant Sci.* 53:317-322.
- MacLean, A. J., and Donovan, L. S. 1973. Effects of soil temperature on early growth of six single-cross corn hybrids. *Can. J. Soil Sci.* 53:128-129.
- Matthewman, W. G., and Harcourt, D. G. 1972. Phenology of egg-laying of the cabbage maggot, *Hylemya brassicae* (Bouché), on early cabbage in eastern Ontario. *Proc. Entomol. Soc. Ont.* 102:28-35.
- Mohr, W. P. 1971. Freeze-thaw damage to protoplasmic structure in high moisture, edible plant tissues. *J. Texture Stud.* 2:316-327.
- Mohr, W. P. 1972. Soggy-centred french fries. *Can. Inst. Food Sci. Technol. J.* 5:179-183.
- Mohr, W. P. 1973. Applesauce "grain". *J. Texture Stud.* 4:263-268.
- Mukerji, M. K. 1973. The development of sampling techniques for populations of the tarnished plant bug, *Lygus lineolaris* (Hemiptera: Miridae). *Res. Popul. Ecol. (Kyoto)* 15:50-63.

- Mukerji, M. K., and Guppy, J. C. 1973. Changes in the lipid and nitrogen content during postembryonic development of *Pseudaletia unipuncta* (Lepidoptera: Noctuidae). Can. Entomol. 105:471-478.
- Mukerji, M. K., and Guppy, J. C. 1973. Quantitative relationship between consumption and excretion by larvae of *Pseudaletia unipuncta* (Lepidoptera: Noctuidae). Can. Entomol. 105:491-492.
- Pomeroy, M. K., and Fowler, D. B. 1973. Use of lethal dose temperature estimates as indices of frost tolerance for wheat cold acclimated under natural and controlled environments. Can. J. Plant Sci. 53:489-494.
- Pratt, J. J., Jr., House, H. L., and Mansingh, A. 1972. Insect control strategies based on nutritional principles. Pages 651-688 in J. G. Rodriguez, ed. Insect and mite nutrition. North Holland Publishing Co., Amsterdam.
- Slykhuis, J. T. 1973. Characteristics of suppression of wheat spindle streak mosaic by nitrogen fertilizers. Can. J. Plant Sci. 53:477-483.
- Voldeng, H. D., and Blackman, C. E. 1973. The interrelated effects of stage of development and seasonal changes in light and temperatures on the components of growth in *Zea mays*. Ann. Bot. (Lond.) 37:895-904.
- Wallen, V. R., Galway, D., Jackson, H. R., and Philpotts, L. E. 1973. Aerial survey for bacterial blight, 1970. Can. Plant Dis. Surv. 53:96-98.
- James, W. C. 1973. Assessing severity of plant diseases. (Evaluation de la gravité des maladies des plantes). Canadex 111.630; 258.630.
- James, W. C. 1973. Development of a model for estimating crop losses due to late blight of potato caused by *Phytophthora infestans*. Proc. 2nd Int. Congr. Plant Pathol. 0588.
- James, W. C. 1973. Disease appraisal and loss: How do we find the answers—a blueprint for tomorrow. Proc. 2nd Int. Congr. Plant Pathol. 0023.
- Schneider, E. F., and Seaman, W. L. 1973. Changes in fine structures during the conversion of conidia cells into chlamydospores in *Fusarium*. Plant Physiol., Suppl. 51. 61 p.
- Slykhuis, J. T., and Barr, D. J. S. 1973. Wheat spindle streak mosaic. Can. Agric. 18(2):18-20.
- Voisey, P. W., Heeney, H. B., and Nonnecke, I. L. 1973. The effect of variety on the relationships between readings from instruments for measuring pea maturity and tenderness. Rep. 6820, Eng. Res. Serv.
- Wallen, V. R. 1973. Quantification of remote sensing systems. Proc. 2nd Int. Congr. Plant Pathol. 0762.
- Wallen, V. R. 1973. Seed quality research symposium: II. Pathological testing. Seed Sci. Technol. 1:201-202.
- Warren, F. S. 1973. Butylate incorporation on corn. Canadex 641.
- Warren, F. S. 1973. Comparative efficiency of weed control by herbicides and/or cultivation for field corn. Res. Rep., Can. Weed Comm., East. Sect., p. 88.
- Warren, F. S. 1973. Delayed incorporation of butylate for annual grass control in field corn. Res. Rep., Can. Weed Comm., East. Sect., p. 87.
- Warren, F. S. 1973. Losses in harvesting grain corn. Can. Agric. 18(4):37-39.

Miscellaneous

- Burrows, V. D. 1973. Daylength insensitive oats. Can. Agric. 18(1):7-9.
- Jackson, H. R., and Wallen, V. R. 1973. Crop and soil studies through photographic remote sensing. Can. Agric. 18(3):19-22.

Research Station

Vineland Station, Ontario

PROFESSIONAL STAFF

A. J. MCGINNIS, B.Sc., M.S., Ph.D.	Director
M. CHIBA, B.Sc., D.Sc.	Residue chemistry
D. R. MENZIES, B.Sc., M.Sc., Ph.D.	Agricultural engineering
W. B. ROSS	Administrative officer
C. M. SIMPSON	Pesticide evaluation

Entomology Section

E. A. C. HAGLEY, B.Sc. (Agr.), M.Sc., Ph.D.	Section Head; Fruit pest management
R. W. FISHER, B.Sc. (Agr.), Ph.D.	Pesticide application
D. H. C. HERNE, B.A., M.S.A., Ph.D.	Acarology
J. H. H. PHILLIPS, B.S.A., M.Sc., Ph.D.	Fruit pest management
A. B. STEVENSON, B.Sc. (Agr.), M.Sc., Ph.D.	Vegetable pest management
R. TROTTIER, B.Sc., M.Sc., Ph.D.	Fruit pest management

Nematology Section

C. F. MARKS, B.Sc. (Agr.), M.S.A., Ph.D.	Section Head; Chemical control
T. H. A. OLT Hof, B.Sc. (Agr.), Ph.D., D.T.A.	Host-parasite relations
J. W. POTTER, B.S.A., M.S.A., Ph.D.	Ecology
J. L. TOWNSHEND, B.Sc., M.Sc., D.I.C.	Ecology

Plant Pathology Section

W. R. ALLEN, B.A., Ph.D.	Section Head; Fruit virology
T. R. DAVIDSON, B.Sc., M.Sc.	Fruit virology
H. F. DIAS, Eng. Agr., Ph.D.	Fruit virology
W. G. KEMP, B.A., M.A.	Vegetable virology
J. NORTHOVER, B.Sc., Ph.D., D.I.C.	Fruit mycology
A. A. REYES, B.S.A., M.S.A., Ph.D.	Vegetable mycology

INTRODUCTION

The experimental orchard sprayer designed last year was built and tested. It functioned according to design specifications, and tests in an apple orchard showed that the experimental sprayer produced only one-quarter as much drift as did a conventional air-blast sprayer.

Insects and mites were controlled in five commercial peach orchards and in one commercial apple orchard by using about one-half the generally recommended amount of pesticide. This reduction in use of chemical was made possible by monitoring the orchards for pest populations throughout the season and applying the chemicals at the most suitable times for effective control. For example, a single application of an acaricide in early July controlled mites until harvest if the population did not exceed 7 to 10 active mites per leaf at the time of spraying.

From one to five pesticide applications can be eliminated without any increase in insect damage by monitoring carrot rust fly populations in carrot fields and applying pesticides accordingly.

Incidence of virus disease in peppers was inversely related to the cleanness of cultivation in the plots. Moreover, a clover crop planted between the rows of peppers reduced the incidence of virus disease from 81% to 32%.

Research also continued on the biology and control of nematodes and on other insects and diseases that attack horticultural crops.

For more information on our research projects or for reprints of published papers, please write: Director, Research Station, Research Branch, Agriculture Canada, Box 185, Vineland Station, Ont. L0R 2E0.

A. J. McGinnis
Director

PESTICIDES

Application

Improved efficiency of application in control of strawberry gray mold. By means of the hydraulic boom sprayer with drop arms developed in 1972, benomyl 50% wettable powder (WP) was applied to strawberries at 1.121, 0.840, and 0.560 kg/ha (1, $\frac{3}{4}$, and $\frac{1}{2}$ lb/ac). Spray coverage was better in 61.0-cm (24-in.) rows than in 91.5-cm (36-in.) rows. Mold was below 1% for all treatments until 4 days after the last spray, and slowly increased to 7% by the 14th day. Efficiency of spraying was increased in the field by doubling the speed to 4.827 km/h (3 mph), halving the amount of chemical applied per unit area, and decreasing the amount of water used from 2.246 kl/ha (200 gal/ac) to 1.123 kl/ha (100 gal/ac). The refill time was decreased accordingly.

Experimental orchard sprayer. The basic machine was constructed and tested to ensure that all systems functioned as designed. Calibration curves were established for hydraulic pressure versus air volume for each of the blowers. A preliminary field test was

carried out to assess the deposit characteristics, and amount of drift from the machine. Fluorescent dye and captan were used, with percentage of fluorescence and micrograms of captan/cm² as criteria for assessing tree and downwind deposits. Drift samples were collected by both horizontal and vertical cards on a 6 × 6 grid with sampling points spaced 10 m apart starting 10 m downwind from the outside row of the orchard. Initial assessment of data indicates that drift was reduced to as little as 25% of that of a conventional air-blast sprayer. For orchard tests in the 1974 season, droplet separation devices will be mounted on the machine to limit the size of droplets emitted.

Metabolism

Metabolism of organophosphorus pesticides. Metabolism of cyanophos (Cyanox; Sumitoto Chemical) and S-4087 (Surecide; Sumitoto Chemical) in bean plants was studied. Both compounds followed the typical metabolic pathway for organophosphorus compounds, but in neither case did the nitrate group seem to be involved. There was a remarkable quantitative difference in the

rate of metabolism between the two. Cyano-phos was lost rapidly from treated leaves and its half-life was 1 day or less, whereas the half-life of S-4087 was about 2 wk. Cyano-phos also dissipated from soil more rapidly than did S-4087. The persistence of S-4087 may cause a residue problem in soils. (The work was carried out at the Tokyo University of Agriculture.)

INSECTS AND MITES

Ecology and Integrated Control

Integrated control of peach pests. The experimental program for management of peach pests was extended in 1973 to five orchards, totaling about 55 ha (136 ac). Pests and pest injury were monitored weekly from bloom to harvest. Sex pheromone traps were used to measure numbers and activity of the oriental fruit moth, and parasitism was estimated by rearing samples of larvae. The European red mite and its predators were estimated from counts made on samples of leaf clusters.

Because of above-average temperatures in July and August, there were four generations of the fruit moth instead of the usual three. The moth numbers in pheromone traps warned of this additional generation in time for an additional spray to be applied. Where the extra spray was not applied, fruit injury was above an acceptable level even where the number of moths trapped was low. This further supports the view that pheromone traps cannot be used to indicate probability of fruit injury. Four sprays of phosmet were necessary on late cultivars to limit insect injury to 1% of the harvested fruit. Where spray coverage was fairly uniform over the trees, phosmet 50 WP at 1.78 kg/ha gave adequate control of the fruit moth. At this rate of application the residue of phosmet averaged 2.14×10^{-6} g/cm² of leaf surface in the best-sprayed orchard.

Corrective rather than protective sprays for the European red mite gave satisfactory control at reduced cost. One spray of propargite 30W at 3.56 kg/ha applied in early July, when active stages of the mite averaged 7 to 10 per leaf, held mites below this number till after harvest of late peaches in mid-September.

High-density peach planting. There was little or no difference in extent of pest

problems on 3-yr-old peach trees planted at densities of 397, 868, and 1,157 trees/ha. Injury by the oriental fruit moth ranged from 4.6% to 14.7% of the harvested fruit, whereas injury by the tarnished plant bug ranged as high as 35%. Average yields were 2,442, 4,484, and 8,151 kg/ha for 397, 868, and 1,157 trees/ha respectively.

Phenology of European red mite development in Ontario apple and peach orchards. Phenological observations on development of overwintering eggs of *Panonychus ulmi* (Koch) in Ontario apple and peach orchards, over a 25-yr period, revealed inconsistent relationships between fruit bud development and hatching dates. In the Jordan-Vineland region, depending on the year, development of Elberta peach buds ranged from swollen to full bloom when mite eggs first hatched. Similarly, in several apple-growing areas, McIntosh apple bud development ranged from green tips to pink when mites first hatched. Depending on the year, the interval between first hatch of mite eggs and bloom ranged from 5 to 18 days on apple, whereas first hatch usually occurred after bloom on peach. For precise timing of miticide applications, essential in integrated control programs, an alternative method for predicting mite development such as degree-day accumulation must be used.

Bioclimatic models for an apple pest monitoring program. The importance of bioclimatic modeling for better timing of pesticide applications in the various apple-growing areas of Ontario has been established. Several predictive models based on weather indexes are now available. To establish a warning system for Ontario, further laboratory and field studies will be carried out on the abiotic factors affecting development and behavior of apple pests.

Management of apple aphid populations. During 1972 and 1973 heavy infestations of the apple aphid, *Aphis pomi* De Geer, occurred in a young McIntosh orchard at Vineland. In 1972, when the trees were 2 yr old, one application of phosalone at 1.5 kg/m³ (1.5 lb/100 gal) applied July 17 satisfactorily reduced aphid numbers. In 1973 the aphid population was maintained at a tolerable level early in the season by several predators, mainly *Campylomma verbasci* Meyer. Several species of syrphids, coccinellids, lacewings, and other mirids were also present

throughout the season. One spray of phosalone at 3–4 kg/m³ (3–4 lb/100 gal) applied July 22 effectively reduced the aphid population, but did not seriously affect occurrence of the main predator.

Monitoring the European red mite and predatory mites. Populations of the European red mite, *P. ulmi* (Koch), and four species of predatory mites, *Amblyseius fallacis* (Garman) (Phytoseiidae), *Zetzellia mali* (Ewing) and *Agistemus fleschneri* Summers (Stigmaeidae), and *Balaustium putmani* Smiley (Erythraeidae), were followed in six apple and five peach orchards under pest management programs. In most orchards *P. ulmi* began to increase rapidly during the first week of July and reached maximum numbers about mid-July during the third generation of the mite. An acaricide applied when the mite population reached 7 to 10 active mites per leaf during early July usually provided control throughout the season. When there were more than 10 mites per leaf in early July two or more sprays were often required for control. During this period of rapid population increase, a delay of even a few days in applying the acaricide could result in failure to control the mites.

Monitoring the carrot rust fly. By monitoring second-generation carrot rust fly adults on sticky traps and timing sprays accordingly, some growers in the Holland Marsh could have saved 1 to 5 insecticide applications in 1973. Plots in six locations to which sprays were applied only when so indicated required an average of 3.3 sprays (range 1 to 5), instead of the 5 to 7 sprays that were normally applied during the same period. Rust fly damage in these plots averaged 2.3% injury at harvest. By determining seasonal development of the rust fly in emergence cages placed in unsprayed plots, sprays could also be timed more effectively. Dates of the first and peak emergence from 1970 to 1973 for both first and second generations of the rust fly varied by as much as a week, indicating that the use of average dates of emergence for timing sprays is unsatisfactory.

Seasonal history of the carrot weevil in Ontario. The carrot weevil has become more widespread in the Holland Marsh since 1970; it attacks both carrots and celery. In 1972 and 1973 overwintered adult weevils began ovipositing about May 25 in 2nd-yr carrots

used as traps. Infestation of the new crop of carrots occurred by June 6 in 1972. In tests on dates of planting, weevils attacked carrots throughout June and most of July, but maximum infestation occurred during the first week of June. In similar studies with celery the most severely damaged were seeded May 18 and 85% of the plants were destroyed. The succeeding generation of adults emerged from late July until October, but caused little subsequent damage.

NEMATODES

Ecology

Soil sampling techniques. To achieve precision such that 95% of the possible estimates of the nematode density in each 4.3 × 24.4-m plot are within 20% of the true mean density, five subsamples from each of five 40-core samples were required. The time required for such sampling is impractical. Estimates of nematode population densities based on one subsample of one 20-core sample per plot, a typical sampling scheme used in field experimentation, indicated that when the true mean density was 500 *P. penetrans* per 0.45 kg of soil, 95% of the counts would be in the interval 150–1,200. It is apparent, therefore, that with general field experimentation high precision cannot be attained in estimating nematode population densities in the soil. In field studies this lack of precision must be accepted and other experimental procedures and conclusions adjusted accordingly.

Hosts of the pin and root-knot nematodes. Host ranges of the pin nematode, *Paratylenchus projectus* Jenkins, and the root-knot nematode, *Meloidogyne hapla* Chitwood, were determined in the greenhouse in separate experiments. For the pin nematode the crops, in decreasing order of suitability, were Empire birdsfoot trefoil, Ottawa red clover, Merit white clover, Stormont oats, Climax timothy, Tetra Petkus rye, Herta barley, Genessee winter wheat, Rideau orchardgrass, and Pride 137 corn. Saranac alfalfa was a questionable host and Saratoga brome grass was not a host. For the root-knot nematode the crops, in decreasing order of suitability, were red clover, birdsfoot trefoil, and alfalfa. Grasses and cereals are not hosts of *M. hapla* and were not tested.

Population densities and crop loss. Three table vegetables and sugar beets were grown in field microplots consisting of 20-cm clay tiles that contained 0, 3,700, 11,100, 33,300, or 100,000 *Heterodera schachtii* larvae/kg of Vineland loam. Losses of marketable produce at these initial densities were, respectively, for Market Prize cabbage 11%, 30%, 62%, and 92%; Idol cauliflower 14%, 28%, 61%, and 94%; Detroit Dark Red beets 43%, 40%, 49%, and 94%; and sugar beets (Monogerm, C.S.F.) 38%, 56%, 64%, and 92%.

Cereal grain yields in relation to nematicide applications. Field plots infested with moderate numbers of root-lesion nematodes, *Pratylenchus neglectus* (Rensch) Chitwood & Oteifa, pin nematodes, *Paratylenchus projectus* Jenkins, and oat-cyst nematodes, *Heterodera avenae* Wollenweber, were fumigated with EP-162 (Vorlex; Nor-Am Agricultural Products Inc.) at 0.089 kl/ha (8 gal/ac) or 0.449 kl/ha (40 gal/ac), or were treated with Bay 68138 (Nemacur; Bayer) 15% granular (G) at 3.4 kg/ha (3 lb/ac) or carbofuran 10G at 6.7 kg/ha (6 lb/ac) prior to spring seeding with Kelsey oats and York barley. Grain yields at harvest showed increases of 112 kg/ha (3 bu/ac), 300 kg/ha (8 bu/ac), and 380 kg/ha (10 bu/ac) with the lower rate of EP-162, Bay 68138, and carbofuran, respectively. These increases at current prices were not sufficient to offset the cost of the chemicals applied. EP-162 was phytotoxic at the higher rate and decreased grain yield.

Fruit Virology

A new disease of grapes. At two locations in the Niagara Peninsula, vines of the cultivar Seibel 9549 showed yellow and curled leaves, short internodes, poor fruit set, and stunting. Indexing is in progress in an effort to identify the disease, which resembles 'flavescence dorée,' a mycoplasma disease known in France and Germany.

Strain-host specificity. Previous work showed that a strain-host specificity, independent of the nematode vector *Xiphinema americanum*, existed for two strains of the tomato ring spot virus (Ontario type and peach yellow bud). Work in 1973 failed to confirm this specificity for the grape yellow vein strain because the nematode did not feed on grape roots. Attempts to transmit this strain to cucumber, grape, peach, and raspberry with nematodes fed on infected grapes

failed. Nematodes fed on infected cucumber did transmit the strain to cucumber, but not to any other host. These results confirm field studies, showing that grape yellow vein disease spreads very slightly, if at all, in infected vineyards.

Peach X-disease. The destructive disease found in some peninsula peach orchards in 1972 has been positively identified as X-disease. Surveys indicate that spread during 1972 varied from 0 to 5% in district orchards.

Fluted and misshapen apple fruits. Over a 4-yr period, a number of apple orchards in the southern Georgian Bay region produced severely misshapen fruits. Trees moved to Vineland outgrew the condition, and neither graft transmission nor virus indexing indicated a virus problem. Apparently the disorder is physiological, presumably induced by effects of repeated low temperatures.

Induction and control of *Leucostoma* lesions on peach shoots. Peach leaf scars exposed in early November were more susceptible to infection and subsequent lesion formation by the peach canker fungus, *Leucostoma cincta* (Fr.) Hohn., than were those exposed in late October. Also, an application of captafol in mid-November was more effective for the control of this type of infection than one made in late October. Consequently, the commercial use of captafol in early November primarily for the control of peach leaf curl, caused by *Taphrina deformans* (Berk.) Tul., will also provide substantial control of *Leucostoma* lesions on shoots.

Precalyx control of apple scab with a single application of captafol. A single application of captafol at late-dormant to half-inch green bud development was an effective alternative to three to six applications of dodine, during the first 6 wk of the growing season, for control of apple scab, caused by *Venturia inaequalis* (Cke.) Wint. Supplementary protectant fungicide programs begun at calyx formation provided excellent control of secondary infections. Delaying these programs until second cover allowed up to 6% fruit infection.

Vegetable Virology

Effect of crop background on epidemiology of stylet-borne virus diseases in peppers. Virus incidence and populations of the aphid vector in pepper plots were reduced by a

clover background crop between the rows. Eighty-one percent of the plants were virus-infected in clean-cultivated plots; 47 and 32% of plants were infected in plots with sparse and heavy cover, respectively. The aphid vector of pepper viruses was also scarce on the clover crop.

Effect of systemic insecticide and summer oil sprays on incidence of aphid-transmitted virus diseases of peppers. Dimethoate sprays failed to reduce aphid-transmitted viruses in peppers, whereas 0.5 and 2.0% summer oil sprays decreased virus incidence by 35 to 45%. Combinations of dimethoate and oil were no better than oil sprays alone. Dimethoate alone and with 0.5 and 2.0% summer oil reduced aphid infestation by approximately 90% at the time of the maximum recorded population per leaf.

Viruses of umbelliferous plants. Two previously unrecorded viruses of carrots in Ontario, one with isometric particles, the other a flexuous rod, have been identified tentatively as a cucumber mosaic virus and a member of the potato virus Y group. Both were isolated from stunted plants with early-maturing, chlorotic-spotted leaves.

Fruit blemishes on glasshouse tomatoes. A tobacco strain of tobacco mosaic virus (TMV) was isolated from severely blemished glasshouse tomatoes, cultivar Ohio W.R. 25, grown in the tobacco region of southwestern Ontario. Under growth-room conditions, the

symptom complex was duplicated by using purified virus with cultivars Michigan Ohio, Ohio W.R. 25, Vantage, Veegan, and Vender. Inoculations made at all truss stages except the first induced fruit blemishes above and below the point of inoculation. As much as half the fruit on affected trusses was blemished. There was no evidence of cross protection with a mild tomato strain of TMV.

Vegetable Mycology

Phytotoxicity of benomyl on crucifers. Symptoms of phytotoxicity of benomyl on crucifers include savoying of the leaves, chlorosis of the leaf margins, and wilting or dwarfing of the plant. Newly germinated crucifer seedlings were more sensitive to benomyl than were transplants. Seedling emergence of Eastern Ballhead cabbage (*Brassica oleracea* var. *capitata* L.) was reduced by benomyl at 0.28 g ai/pot in the greenhouse at soil temperatures of 70° or 80°F (20° or 27°C), but not at 40° or 50°F (4° or 10°C). The insecticide chlorfenvinfos used to control the cabbage maggot, *Hylemya brassicae* Bouché, was compatible with benomyl when mixed with it in transplant water, and good control of clubroot, caused by *Plasmodiophora brassicae* Wor., was obtained. Chlorfenvinfos alone has no effect on clubroot. The spreader Tween 20 (polyoxyethylene sorbitan monolaurate) was not phytotoxic to seedlings and when added to benomyl for clubroot control resulted in increased plant growth and greater marketable yield.

PUBLICATIONS

Research

- Bond, E. J., Herne, D. H. C., and Dumas, T. 1973. Control of overwintering stages of mites on apples using ethylene dibromide. *Can. Entomol.* 105:903-908.
- Chiba, M. 1972. Environmental pollution by pesticides and polychlorinated biphenyls and the biological significance of their residues in food. *New Food Ind.* 14:17-24 (In Japanese).
- Chiba, M. 1973. Polychlorinated biphenyls in the environment and their analysis. Lattis Publishing Co., Tokyo. 236 pp. (In Japanese).
- Chiba, M., Fisher, R. W., Northover, J., Herne, D. C., and Neff, A. 1973. Evaluation of three types of vineyard sprayers by measurement of carbaryl deposit, dye distribution, and control of powdery mildew and two-spotted mite. *Can. J. Plant Sci.* 53:189-197.
- Fisher, R. W., and Hikichi, A. 1973. Control of botrytis rot in strawberries with captan applied from a boom sprayer with drop arms. *Proc. Entomol. Soc. Ont.* 103:40-46.
- Fisher, R. W., and Hikichi, A. 1973. Efficiency of an air-blast sprayer in applying a fungicide to control botrytis rot in strawberries. *Proc. Entomol. Soc. Ont.* 103:47-54.

- Fisher, R. W., and Menzies, D. R. 1973. Relationship of spatial density of spray droplet to frequency of contact by European red mite (Acarina: Tetranychidae). *Can. Entomol.* 105:999-1001.
- Hagley, E. A. C. 1973. Timing sprays for codling moth (Lepidoptera: Olethreutidae) control on apple. *Can. Entomol.* 105:1085-1089.
- Hagley, E. A. C., and Hikichi, A. 1973. The arthropod fauna in unsprayed apple orchards in Ontario. 1. Major pest species. *Proc. Entomol. Soc. Ont.* 103:60-63.
- Herne, D. H. C. 1973. Methodology for assessing resistance in the European red mite. *Proc. 3rd Int. Congr. Acarology, Prague.* pp. 663-667.
- Herne, D. H. C., Simpson, C. M., and Townshend, J. L. 1973. Aldicarb: a systemic soil pesticide useful for establishing apple plantings. *Proc. Entomol. Soc. Ont.* 103:27-29.
- Kasting, R., and McGinnis, A. J. 1973. Construction and operation of a 'clean room' to avoid infectious disease when rearing the pale western cutworm. *Lab. Pract.* 33:368-369.
- Marks, C. F., and Elliot, J. M. 1973. Damage to flue-cured tobacco by the needle nematode *Longidorus elongatus*. *Can. J. Plant Sci.* 53:689-692.
- Marks, C. F., Saidak, W. J., and Johnson, P. W. 1973. Effects of soil management on numbers of the root-lesion nematode *Pratylenchus penetrans* in soils of Ontario peach orchards. *Can. J. Plant Sci.* 53:181-185.
- Marks, C. F., and Townshend, J. L. 1973. Multiplication of the root lesion nematode *Pratylenchus penetrans* under orchard cover crops. *Can. J. Plant Sci.* 53:187-188.
- McGinnis, A. J., and Kasting, R. 1973. Quantitative nutrition and evaluation of protein in foods of phytophagous insects. Pages 57-71 in J. G. Rodriguez, ed. *Insect and mite nutrition.* North-Holland, Amsterdam. 1972.
- McGinnis, A. J., and Loschiavo, S. R. 1973. Repellency of wheat germ extracts prepared with peroxide-containing ether to adults of *Tribolium confusum* (Coleoptera: Tenebrionidae). *Can. Entomol.* 105:133-137.
- Olthof, T. H. A., and Hopper, B. E. 1973. Distribution of *Pratylenchus* spp. and other stylet-bearing nematode genera in soils in the flue-cured tobacco area of southern Ontario. *Can. Plant Dis. Surv.* 53:31-33.
- Olthof, T. H. A., Marks, C. F., and Elliot, J. M. 1973. Relationship between population densities of *Pratylenchus penetrans* and crop losses in flue-cured tobacco in Ontario. *J. Nematol.* 5:158-162.
- Olthof, T. H. A., and Potter, J. W. 1973. The relationship between population densities of *Pratylenchus penetrans* and crop losses in summer-maturing vegetables in Ontario. *Phytopathology* 63:577-582.
- Phillips, J. H. H. 1973. Monitoring for oriental fruit moth with synthetic sex pheromone. *Environ. Entomol.* 2:1039-1042.
- Potter, J. W., and Townshend, J. L. 1973. Distribution of plant parasitic nematodes in field crop soils of southwestern and central Ontario. *Can. Plant Dis. Surv.* 53:39-48.
- Reyes, A. A., and Chadha, K. C. 1973. Interaction between *Fusarium oxysporum* f. sp. *conglutinans* and turnip mosaic virus in *Brassica campestris* var. *chinensis* seedlings. *Phytopathology* 62:1424-1428.
- Stevenson, A. B., and Roberts, M.-D. 1973. Tarnished plant bug rearing on lettuce. *J. Econ. Entomol.* 66:1354-1355.
- Townshend, J. L. 1973. Survival of *Pratylenchus penetrans* and *P. minyus* in two Ontario soils. *Nematologica* 19:35-42.
- Townshend, J. L., Potter, J. W., Marks, C. F., and Loughton, A. 1973. The pin nematode, *Paratylenchus projectus*, in rhubarb in Ontario. *Can. J. Plant Sci.* 53:377-381.
- Trottier, R. 1973. A controlled temperature and humidity cabinet for recording the emergence behaviour of aquatic insects. *Can. Entomol.* 105:971-974.
- Trottier, R. 1973. Influence of temperature and humidity on the emergence behaviour of *Anax junius* (Odonata: Aeshnidae). *Can. Entomol.* 105:975-984.
- Wu, L. Y., and Townshend, J. L. 1973. *Paratylenchus tateae* n. sp. (Paratylenchinae, Nematoda). *Can. J. Zool.* 51:109-111.

Miscellaneous

- Dustan, G. G., and Davidson, T. R. 1973. Diseases, insects and mites of stone fruits. *Can. Dep. Agr. Publ.* 915. 59 pp. Revised.
- Herne, D. H. C. 1973. Effect of pesticides on beneficial insects and mites. *Canadex* 605.
- Marks, C. F. 1973. Nematicides in the soil environment. *Canadex* 628.
- Marks, C. F., and Elliot, J. M. 1973. Nematicides in the soil environment. *The Lighter* 43(2):18-29.
- McGinnis, A. J. 1973. Research Station function varied. *The Grower* 22(8):8.
- Northover, J. 1973. New developments in the control of peach canker. *The Mountaineer Grower* 324:17-19.

- Northover, J. 1973. Questions about peach leaf curl. Can. Fruitgrower 29(8):19-21.
- Olthof, T. H. A. 1973. When to control tobacco nematodes. Can. Tob. Grower 21(9):10-12.
- Olthof, T. H. A., Marks, C. F., Potter, J. W., and Townshend, J. L. 1973. Economically important plant parasitic nematodes in Ontario. Proc. Entomol. Soc. Ont. 103:7-9.
- Olthof, T. H. A., and Potter, J. W. 1973. *Meloidogyne hapla* miscellaneous vegetable crops. FAO Manual, Crop Loss Assessment Methods, Ser. 262, Suppl. 1. Spec. Method 109.
- Townshend, J. L., and Marks, C. F. 1973. Nematodes reduce profits in greenhouse roses. Can. Florist.

Animal Research Institute

Ottawa, Ontario

PROFESSIONAL STAFF

R. S. GOWE, B.S.A., M.Sc., Ph.D.	Director
D. A. LEGER, B.Sc.	Technical Requirements Officer
G. B. MATTHEWS	Chief, Administration and Resources
G. T. SPURR, B.A.	Administrative Services

Scientific Support

G. P. KAVANAGH	Computer systems
K. B. LAST ¹	Computer systems and programming
V. LAWETZ, ^{1,2} B.Sc., Ph.D.	Computer systems
C. P. O'BRIEN, ¹ B.Sc.	Computer programming

Dairy Cattle and Poultry Breeding Section

G. R. BARR, B.S.A., M.S.A., Ph.D.	Chief of Section; Dairy cattle breeding
J. A. B. EMSLEY, ³ B.Sc., Ph.D.	Dairy cattle breeding
J. S. GAVORA, Ing., C.Sc.	Poultry breeding, disease resistance
R. S. GOWE, B.S.A., M.Sc., Ph.D.	Poultry breeding, egg production
A. A. GRUNDER, B.S.A., M.Sc., Ph.D.	Poultry breeding, disease resistance
C. G. HICKMAN, B.S.A., M.S., Ph.D.	Dairy cattle breeding
K. G. HOLLANDS, B.S., B.S.A., M.S.A.	Poultry breeding, physiological traits
W. E. LENTZ, B.Sc., M.Sc., Ph.D.	Poultry breeding, egg production
J. NAGAI, B.A., D.Agr.	Mouse genetics
H. F. PETERS, B.S.A., M.S., Ph.D.	Sheep breeding

Monogastric Nutrition Section

G. A. LODGE, B.Sc., Ph.D.	Chief of Section; Swine, energy metabolism
J. D. CIPERA, Ing., M.S.A., Ph.D.	Poultry nutrition, proteins
J. I. ELLIOT, B.S.A., M.Sc., Ph.D.	Swine nutrition, baby pigs

D. W. FRIEND, B.Sc., M.S., Ph.D.
 R. M. G. HAMILTON,³ B.Sc., M.Sc., Ph.D.
 N. K. SARKAR, B.Sc., M.Sc., Ph.D.
 I. R. SIBBALD, B.Sc., M.Sc., Ph.D.

Swine nutrition, sows
 Poultry nutrition, egg quality
 Poultry, protein metabolism
 Poultry, energy utilization

Reproductive Physiology Section

L. AINSWORTH, B.Sc., M.Sc., Ph.D.
 A. J. HACKETT,⁴ D.V.M., M.Sc., Ph.D.
 W. G. HUNSAKER, B.S.A., M.S.A., Ph.D.
 H. A. ROBERTSON, B.Sc., Ph.D., F.R.I.C., F.R.S.E.
 C. P. W. TSANG, B.Sc., M.Sc., Ph.D.
 F. A. VANDENHEUVEL, B.Sc., M.Sc., Ph.D., D.I.C.,
 F.C.I.C.

Chief of Section; Steroid hormones
 and reproduction
 Reproductive and light physiology
 Reproductive physiology
 Reproductive physiology
 Steroid hormones
 Steroid identification

Ruminant Nutrition Section

F. D. SAUER, D.V.M., M.S., Ph.D.
 J. D. ERFLE, B.S.A., M.Sc., Ph.D.
 L. J. FISHER, B.S.A., M.Sc., Ph.D.
 D. P. HEANEY, B.S., M.S., Ph.D.
 H. W. HULAN,⁵ B.Sc., M.Sc., Ph.D.
 W. A. JORDAN, B.S.A.
 J. R. LESSARD, B.S., B.S.A., M.S., Ph.D.
 E. E. LISTER, B.Sc., M.Sc., Ph.D.
 S. MAHADEVAN, B.Sc., M.Sc., Ph.D.
 D. S. WALSH (Mrs.), B.A.

Chief of Section; Rumen
 metabolism
 Rumen metabolism and metabolic
 diseases
 Dairy cattle nutrition, proteins and
 energy, pollution
 Forage conservation and evaluation
 Rapeseed oil nutrition
 Beef cattle nutrition
 Forage conservation
 Beef cattle and calf nutrition
 Short-chain and long-chain fatty
 acid metabolism
 Hormones of energy metabolism

Trace Minerals and Pesticides Section

K. J. JENKINS, B.Sc., M.Sc., Ph.D.
 T. S. FOSTER, B.Sc., M.Sc., Ph.D.
 M. HIDIROGLOU, D.V.M., D.N.
 J. K. G. KRAMER, B.Sc., M.Sc., Ph.D.

Chief of Section; Selenium
 metabolism and nutrition
 Pesticide metabolism and residues
 Selenium and vitamin E nutrition
 Pesticide syntheses and analyses

Departures

J. R. AITKEN, B.S.A., M.Sc., Ph.D.
 Appointed Research Coordinator (Animal Science),
 Ottawa, March 1973

Poultry nutrition, proteins

J. E. GAZELEY (Mrs.), B.A., B.L.S. Transferred to Department of Manpower & Immigration, Ottawa, August 1973	Librarian
J. R. HUNT, B.S.A., Ph.D. Transferred to Research Station, Agassiz, B.C., September 1973	Poultry nutrition, egg quality
E. S. MERRITT, B.Sc. (Agr.), M.Sc., Ph.D. Appointed Research Coordinator (Animal Breeding), Ottawa, May 1973	Poultry breeding, broilers and geese
M. ZAWALSKY, ¹ B.S.A., M.S. Transferred to Research Station, Brandon, Man., April 1973	Computer systems and programming

VISITING SCIENTISTS

National Research Council postdoctorate fellows

A. S. ATWAL, B.Sc., M.Sc., Ph.D., 1971-73	Ruminant ketosis
H. M. MUKHOTY, B.V.Sc., M.Sc., Ph.D., 1972-74	Sheep breeding and meat quality
E. IBRAHIM, B.Sc. (Agr.), M.Sc., Ph.D., 1973-74	Ruminant nutrition

¹Seconded from Data Processing Service.

²Assigned to Animal Research Institute, April 1973.

³Appointed November 1973.

⁴Appointed December 1973.

⁵Appointed March 1973.

INTRODUCTION

During the year the reproductive physiology program was strengthened and the experimental work diversified. More experimental work is being directed toward the development of the applied program on reproduction of sheep and cattle.

The multidisciplinary program on the nutritional value of rapeseed oil was expanded and intensified. This program involves biochemists, nutritionists, and organic chemists in this Institute, and pathologists in the Animal Diseases Research Institute.

This report records only the highlights of our research in 1973; more detailed information is available in the publications listed at the end of the report. Reprints of the research publications and copies of this report are available on request from Animal Research Institute, Headquarters Building, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

R. S. Gowe
Director

ANIMAL AND POULTRY BREEDING

Poultry

Genetic resistance to Marek's disease. Research on Marek's disease (MD) was continued in cooperation with the Animal Diseases Research Institute, Hull, Que.

A survey of mortality in 18 strains of chickens at the Animal Research Institute was completed. In Leghorn hens vaccinated for MD and kept to 497 days of age, mortality due to MD was 2.1% and total mortality 11%. In vaccinated and nonvaccinated meat-type hens observed to 392 days of age, the mortality due to MD was 5.4% and 16.4% and total mortality was 27.1% and 43.7%. The results indicated that, although the losses from MD were significantly reduced by vaccination, MD still remains an economically important disease. Mortality from lymphoid leukosis, another disease of the avian leukosis complex, was relatively low (1.2–3.4%) and was not affected by vaccination. Strain of chickens significantly influenced MD mortality, lymphoid leukosis mortality, and total mortality.

In another study, the relationship between resistance to MD and production traits was examined. The results suggested that the observed positive genetic correlation between resistance to MD and rate of egg production would tend to maintain or increase genetic resistance to MD in populations under selection for high egg production. Resistance to MD may decrease in populations selected for

rapid growth because of a negative correlation between resistance to MD and body weight.

A study of 12 blood group systems in several populations of chickens did not reveal any obvious relationship between resistance to MD and red blood cell antigens.

Blood pressure and production traits. Indirect systolic blood pressures of egg-type chickens were higher in males than in females. Additive type of genetic inheritance was indicated with a heritability estimate of 0.26 for females over five generations. In two related strains, the mean blood pressure of the birds that died before 500 days of age was lower than that of the survivors. In a third and unrelated strain, no relationship was found between blood pressure and mortality. A significant strain by sex interaction was observed in blood pressure. Genetic correlations between blood pressure and economic traits were low: blood pressure was positively correlated with body weights and most egg quality traits but negatively correlated with egg production and age at first egg.

Dairy Cattle

Field test of Finnish Ayrshires. A comparison of proven Finnish, proven Canadian, and young Canadian Ayrshire sires in cooperation with 60 breeders of registered Ayrshires in Quebec and Ontario is continuing as calves are born. In Ontario, the three groups of matings have so far yielded 114 bull calves and 134 heifers. In Quebec, where 1,000 matings were made using semen from proven

Finnish and proven Canadian bulls, 36 bull calves and 38 heifer calves have been born.

Cooperating breeders were consulted for assistance in developing forms for recording information on the calves and in planning data-gathering procedures. Sire evaluation will be based on milk and butterfat production in first lactations for daughters of all bulls in the project.

Evaluation of selection and crossbreeding. This project was designed to take advantage of expected improvement in livability and reproductive efficiency from crossbreeding. The two pure lines being used to develop the crossbred line (C) are Holstein (H) and a synthetic (A) consisting mainly of Ayrshire with the addition of Brown Swiss, Norwegian Red, and Finnish Ayrshire. Matings of superior cows using semen from outstanding AI bulls were completed, and the prescribed number of bull calves were selected. One-quarter of the H and A females will be bred by the selected bull calves to produce C-line females.

Comparative studies of growth and livability are planned for the A-line, H-line, and C-line animals. Facilities used in this project also provide a means of studying production and management techniques for large-scale dairy operations. The data acquisition and processing system (DAPS) provides, at regular intervals, a contemporary evaluation of all heifers and their sires based on level of milk-protein production. Also, all scheduling and inventory control for herds cooperating in this project at Lethbridge, Normandin, Lennoxville, Charlottetown, and Ottawa are performed weekly by the DAPS.

Mouse research. Data from two populations (P and Q) of different origin were analyzed to construct a selection index combining the average body weight of individuals within a nursed litter at 12 days (m) and the body weight of individuals of a nursed litter at 42 days (w). The nursed litter contained eight young from four dams. The index constructed for P was $I = w - 0.17m$ and for Q, $I = w + 0.18m$. These indexes indicate that major emphasis is placed on w when the two traits are to be selected concurrently. An experiment using a line (M) selected for m , a line (W) selected for w , and a line (B) selected for both m and w showed that response in m for B relative to M and the response in w for B relative to W were larger

in P than in Q. There was evidence suggesting that milk production could be improved more effectively by selecting for w than for m .

Sheep

The effect of environment on reproduction of the ewe. Studies are continuing on the effect of ambient temperature and various light treatments on the reproductive performance of the Suffolk ewe. During May and June 1973, 85% of a group of ewes in a reverse-phase light regime were bred successfully. Of a group born and raised in a constant regime of 10 h of light and 14 h of dark, 73% conceived when bred during October and November 1972 and 55% conceived when they were rebred during May and June 1973.

Increasing lambing percentage. The number of lambs born per ewe in the breeding flock has been increased from 0.33 in yearling ewes and 1.33 in mature ewes in 1967 to 0.90 in yearling ewes and 1.58 in mature ewes in 1973. These increases resulted from improvement in both conception rate and prolificacy.

In 1973 at the Greenbelt Farm, the percentages of ewes that lambled were 39% of the sire-strain, 32% of the Suffolk strain, and 79% of the dam-strain for yearling ewes; and 84%, 84%, and 91% for mature ewes of these populations. The corresponding numbers of lambs born per ewe lambled were 1.08, 1.17, and 1.39 for yearling ewes and 1.54, 1.74, and 1.98 for mature ewes. The sire-strain group consisted of the Ottawa MM strain and related crosses. Of the dam-strain group, 46% carried Finnish Landrace ancestry. Of the 12 yearling and 28 mature Finnish Landrace purebred ewes, 75% of the yearling and 96% of the mature ewes lambled, with 2.11 and 2.89 lambs born per ewe lambing.

Distribution of muscle weight in lamb carcasses. A study was completed on the influence of breed (sire-strain vs. half-Finnish Landrace crossbreds) and sex on the weight of muscle in eight joints of lamb carcasses. No major difference was detected in distribution of muscle weight between the two breed groups. Ram lambs showed more muscle weight in the neck region, and ewe lambs showed slightly more leg muscle. At comparable carcass weight, the Finnish-cross lambs exceeded the sire-strain lambs in intermuscular, internal, and total fat content,

despite a lower content of subcutaneous fat; but, because of a higher muscle-to-bone ratio, the Finnish-cross lambs were similar to the sire-strain lambs in total muscle content. Ewe lambs carried more fat, and despite a slightly higher muscle-to-bone ratio, they were lower than the ram lambs in total muscle content.

MONOGASTRIC NUTRITION

Poultry

Growth restriction of broiler breeder stock. The feeding of whole wheat plus supplementary vitamin D, calcium, and phosphorus to two strains of birds from 8 to 21, 12 to 21, or 16 to 21 wk of age was compared with feeding a 14% protein mash (control) on alternate days. Sexual maturity (age at 25% production) was influenced in both strains tested. Maturity was reached on the different treatments at approximately half-weekly intervals in the order 16-21, 12-21, control, and 8-21. In egg production, both strains peaked 5% higher on the control than on the other rearing treatments. At 69 wk of age, one strain showed a favorable response in egg production to the control treatment, whereas the other strain did not. Feeding whole wheat from 8 to 21 wk gave the poorest egg production in both strains, but mortality, egg size, fertility, hatchability, and growth rate of the progeny were not affected by rearing treatment. Rearing treatment dramatically influenced body weight at housing (21 wk of age) and, although these treatment differences had diminished by 33 wk (when the birds had reached their maximum body size), they still ranked in the order 16-21 (heaviest), 12-21, control, and 8-21.

Factors affecting eggshell formation. In feeding trials with laying hens, 17 strains or strain-crosses were fed 5% of their dietary calcium carbonate as particled limestone or oyster shell or as finely ground limestone. No effect was detected on eggshell quality or on any of the other production traits measured. These results were the same as those of the previous year, when the control birds were fed pulverized (feed grade) limestone. Using a ⁴⁵Ca-labeled Ca supplement, it was shown that during shell formation the transfer of dietary Ca from the digestive tract to the eggshell is almost immediate; a small portion

is incorporated into the skeletal system and a large portion is voided in the excreta.

Protein content, digestibility, and lysine availability of Canadian cereals. Twenty-five samples of wheat, 15 of oats, and 12 of barley, representing various varieties, species, and years of production, were analyzed for their protein content. The results varied from 9% to 21% in wheat, from 11% to 19% in oats, and from 10% to 14% in barley. The total amount of amino acids released (digestibility) when different amounts of wheat, oats, and barley containing 20 mg of protein were initially digested by 4 mg pepsin at pH 2.0 for 1 h and then by 8 mg chick pancreatin at pH 8.0 for 3 (or 5) h showed differences between cereals, but no significant differences were observed between samples within cereals. Available lysine, determined by a modification of Carpenter's method and multiplied by a correction factor of 1.2, yielded data of a similar pattern.

Swine

Age of puberty in gilts. Gilts were fed equal, but limited amounts of a basal corn diet, the basal diet plus lysine, or a corn-soybean diet. In a study that compared their ages at puberty with that of a positive control group fed ad lib. the corn-soybean diet, the control gilts reached puberty at 173 days of age compared with ($P < 0.01$) 201, 200, and 194 days for the other three groups. The control gilts were heavier at puberty and their average daily gains greater ($P < 0.01$) than those of the other gilts. This was due partly to greater daily feed consumption and the improved feed efficiency ($P < 0.01$) of the controls.

REPRODUCTIVE PHYSIOLOGY

Hormones in Body Fluids and Tissues

The synthesis of over 300 commercially unavailable neutral steroids and a study of their properties by gas-liquid chromatography (GLC) and thin layer chromatography (TLC) has allowed the development of a faster, more effective method, based on the correlation of GLC retention time with steroid structure, of identifying neutral steroids extracted from body fluids and tissues.

Changes in plasma levels of progesterone and estrogens during pregnancy and at

parturition in the sow have been determined. The mean plasma level of progesterone ($n = 5$) remained fairly constant at 13 ng/ml until day 90 of pregnancy, when a gradual decline began that continued to a mean level of 4.7 ng/ml on the day of parturition (day 114). A further rapid decline to < 0.5 ng/ml occurred within 24 h of farrowing. Estrone and estradiol-17 β were first detected in plasma between days 70 and 80 of pregnancy, and the mean levels ($n = 5$) rose steadily to peaks of 4 ng/ml and 250 pg/ml just before parturition. After parturition the plasma estrogen levels dropped rapidly to < 15 pg/ml.

In an attempt to gain some insight into the physiological significance of estrogen sulfates, plasma levels of estrone sulfate were measured throughout pregnancy in the sow and for 80 h (before, during, and after parturition) in the sheep. In the sow, the plasma level of estrone sulfate (assessed as estrone equivalents) began to rise at day 16 of pregnancy and peaked at 3 ng/ml between days 23 and 30. The plasma level declined sharply to a low of 35 pg/ml on about day 50 and then rose gradually to a second peak of 3 ng/ml on the day before parturition. The second rise was similar to that observed for estrone and estradiol-17 β during the second half of pregnancy. In the sheep, a rapid rise in the plasma levels of estrone and estrone sulfate began about 40 h before parturition, reached a peak at parturition, and then dropped rapidly to nondetectable levels by 15 h after parturition. The mean plasma level of estrone sulfate ($n = 8$) at the peak was 82.5 pmol/ml compared to a mean plasma level of 3.3 pmol/ml for estrone. Work on the synthesis of steroid sulfates during pregnancy in domestic species has demonstrated that fetal liver tissue of the pig has the capacity to synthesize sulfates of neutral and phenolic steroids.

An ovine placental somatomammotropic hormone, differing from ovine pituitary prolactin, has been identified in the plasma of pregnant sheep. Its concentration in maternal plasma has been measured throughout pregnancy and the changes in plasma concentration have been found to correlate very closely with the changes in plasma progesterone. Tests have failed to detect the presence of a similar placental hormone in the maternal plasma of the cow and the pig during pregnancy.

Biorhythms—Behavior and Reproductive Function

Several physiological, behavioral, and environmental parameters in a group of sheep have been recorded continuously for several months with the aid of a computerized data acquisition system. Computer programs have been set up for initial summarization and time series analysis, and for preparation of analogue plots and chronograms of the data. These programs will be used to establish biorhythms for the parameters recorded. The effect of intensity and duration of light on these biorhythms will be studied to determine whether these rhythms can be used as an indirect measurement of the rhythm of sensitivity to light and whether they can be correlated with changes in reproductive function in sheep. A telemetric system designed to record copulation in sheep and the data acquisition system are being used to record the mating pattern in a group of sheep throughout the breeding season.

RUMINANT NUTRITION

Beef Cattle Nutrition

Dairy beef production on corn silage diets. One hundred and twenty Holstein-Friesian steers were fed diets made up of various proportions of corn silage and concentrates. Those steers fed a ration in which corn silage made up 60% or 90% of the dry matter (DM) grew more slowly than steers fed all-concentrate diets or rations in which 30% of the DM was corn silage. Feed DM per unit gain was 5.64, 6.18, 6.33, and 6.46 for all-concentrate diets, and diets having 30%, 60%, and 90% of DM from corn silage. When the highest amount of corn silage DM was fed, dressing percent and fat thickness over the longissimus dorsi were reduced and cooler shrink was increased. There was a progressive increase in feed required per unit gain, dressing percent, area of longissimus dorsi, and fat thickness, but a decrease in the proportion of the carcass in the hindquarter as liveweight at slaughter increased.

Housing and weaning age on feed requirements. At Kapuskasing, Ont., Shorthorn cows were kept either in a warm barn (In-warm), an uninsulated cold barn (In-cold), or out-of-doors with a wind shelter (Out) and fed 1.35, 1.45, or 1.80 kg DM/100 kg initial weight

until calving under the three confinement systems (In-warm, In-cold, Out). Confinement systems with their appropriate feeding level resulted in similar weight losses by the cows during the winter. Calves weaned at 48 h resulted in poorer growth rate to 120 days (672 g/day) compared with 820 and 918 g/day to 120 days for calves weaned at 56 and 120 days. Estimated annual digestible energy (DE) required for a cow and her calf to 120 days, after allowing for weight losses of cows and differences in growth rates of calves, was 5,970, 6,360, and 6,560 Mcal DE for weaning at 48 h, 56 days, or 120 days, and 5,850, 6,170, and 6,880 Mcal DE for cows confined In-warm, In-cold, and Out.

Sheep Nutrition

Intensive rearing of lambs. During 1973 the age at which lambs were abruptly weaned from milk replacer was successfully reduced to 21 days. Death losses during the liquid-feeding phase were 9% and were inversely related to litter size and birth weight. Over 70% of the mortality occurred during the 1st wk. The overall average daily gain on milk replacer (1,140 lambs were weaned) was 249 g.

After weaning (from 21 to 140 days of age), high-concentrate diets were fed. Neither an increase of protein in the diet from 17% to 20% for the first 5 wk after weaning nor a reduction of protein from 17% to 14% at 100 days of age affected the rates of gain. When 30% of the dietary crude protein was provided in the form of urea, lamb gains were reduced. However, the age at which urea feeding was started (21 vs. 56 days) did not appear to affect results, indicating that the 3-wk-old lamb is able to adapt to urea as well as the 8-wk-old lamb under intensive conditions.

Energy needs of the pregnant ewe. When fed a high-energy diet ad lib., pregnant ewes maintained maternal body composition during the last 5 wk of pregnancy, whereas nonpregnant ewes on the same diet gained body protein, fat, and water. Of particular significance was the fact that free fatty acid (FFA) levels in the plasma rose markedly during late pregnancy, a phenomenon usually attributed to fat catabolism and, therefore, assumed to be indicative of malnutrition. However, the ewes were fed ad lib. and there appeared, in fact, to be no loss in maternal energy reserves. This suggests that

elevated levels of FFA in the plasma are normal during pregnancy and that attempting to feed to prevent such elevation would greatly overestimate true energy needs.

Dairy Cattle Nutrition

Oat silage for lactating cows. Corn silage ensiled at 33% DM (treatment CS), oats harvested at the milk stage of maturity and ensiled with oat grain (treatment OG), oats harvested at the milk stage of maturity and wilted before ensiling (treatment OM), and oats harvested at the soft-dough stage of maturity and ensiled (treatment OSD) were fed to each of 16 lactating cows during four successive 49-day periods, following a switchback design. The silages as fed contained 34.5, 34.2, 31.9, and 36.6% DM and 8.6, 14.0, 14.4, and 10.5% protein for treatments, CS, OG, OM, and OSD. The intake of forage DM was significantly greater ($P < 0.01$) on treatment OG than on CS and significantly less ($P < 0.01$) on treatment OM than on CS, OG, or OSD. Milk yield was significantly higher ($P < 0.05$) on treatment OG than on OM. There was no significant effect ($P > 0.05$) of treatment on the acetate-to-propionate ratio in the rumen fluid; however, molar percent of rumen butyrate was significantly lower ($P < 0.05$) on treatment OM than on CS or OG. The apparent digestibilities of silage DM were 58.6, 58.0, 60.8, and 52.9, and of silage crude protein were 43.3, 65.3, 63.8, and 55.0 for treatments CS, OG, OM, and OSD.

Amino acid synthesis in mixed rumen culture. An artificial rumen for continuous culture of rumen microflora has been established and kinetics of ^{14}C fixation in bacterial proteins are being measured. The results indicate that the synthesis of glutamate and aspartate is faster than that of other amino acids.

Production and utilization of ammonia in the rumen. To regulate the rate of release of ammonia from nonprotein nitrogen sources in the rumen, detailed studies on the properties of the rumen urease systems were undertaken. For the first time, stable purified urease from rumen microorganisms was isolated by a procedure that consisted of sonication of bacterial suspensions containing 50 mM of Cleland's reagent, followed by fractionation with ammonium sulfate and

Sephadex column chromatography. The purified urease was maximally active at pH 7.0–7.5, was not metal-ion dependent, but was inhibited by Mn^{++} , Mg^{++} , Sr, Ba, Co^{++} , and sulfhydryl blocking reagents. The K_m for urea was 4 mM. The enzyme was inhibited reversibly by hydroxyurea and irreversibly by phenylurea, acetohydroxamate, and a number of amino acid hydroxamates. The inhibition by hydroxyurea and the hydroxamates was dependent on the concentration of the inhibitor and the length of time the enzyme was incubated with the inhibitor. Hydroxyurea was found to be substrate for rumen urease, being hydrolyzed about 150 times slower than urea. Other urea derivatives with substituents on one or both N atoms are being investigated as possible substrates for the slow release of ammonia by rumen urease.

Carnitine levels in milk during the first 8 wk of lactation and in various tissues of dry and lactating cows. The level of milk carnitine in cows was high (0.5 μ moles/ml) at parturition, but it decreased thereafter. The rate at which the concentrations of milk carnitine decreased after parturition was highest in control cows and lowest in ketotic cows. The difference between the level of milk carnitine in the control and the level in ketotic animals was greatest during the 3rd wk ($P < 0.05$) of lactation when concentrations of blood metabolites indicated symptoms of ketosis (decreased glucose and increased ketones and levels of FFA). Correlation coefficients calculated for milk carnitine and blood metabolites showed that during ketosis elevated ketones and levels of FFA and decreased glucose are associated with high concentrations of milk carnitine. Tissue carnitine did not appear altered by stage of lactation, as shown in dry, early-, and late-lactation cows. The concentration of carnitine was highest in skeletal muscle (3–4 μ moles/g wet weight) and heart (1 μ mole/g wet weight), and lowest in other organs (0.075 to 0.15 μ moles/g). The levels of blood carnitine found in the tissues of a ketotic cow were three times higher than in those of normal (control) animals. These changes in tissue carnitine in the ketotic cow do not agree with the increased turnover and decreased body pool size found in other animals under stress.

Nutrition of rapeseed oil. The nutritional and biochemical properties of *Brassica napus*

cultivar Oro and *Brassica campestris* cultivars Arlo, Echo, and Span were studied. The content of free and total fatty acids in heart tissue of rats fed regular (a mixture of Arlo and Echo) and Span rapeseed oils, but not Oro rapeseed oil, increased significantly compared with that of controls. Elevated levels of C-22 and C-20 monoenoic acids were detected in both neutral and polar lipids. The possibility that free fatty acids may cause uncoupling of oxidative phosphorylation and impaired respiration in mitochondria of heart muscle was investigated, and negative results were obtained. These results do not agree with those obtained by research workers at Unilever Research, Vlaardingen (The Netherlands). Boars (105 animals) and gilts (105 animals) were fed a diet of 10% and 20% soybean or Span rapeseed oil for 16 wk. Average weight gain and feed efficiency was higher with the two vegetable oils than with the control, this improvement being shown by increased backfat thickness. Careful histopathological examination of the 210 pig hearts showed no fibrotic lesions, as were found in male rats fed rapeseed oils. Also, the incidence of minute infiltrative lesions was the same for both groups that had been fed soybean oil and Span oil. The incidence of fat accumulation in the heart was apparently slightly greater in pigs fed Span oil than in pigs fed soybean oil.

Span rapeseed oil (2 t) was fractionated by molecular distillation to determine whether the pure triglycerides or some other fraction was responsible for cardiac myopathy observed in male Sprague-Dawley rats. Eleven separate fractions were obtained. The fractionation separated pure triglycerides (3.2–7.3% erucate) from unsaponifiable components. Fractions with 20-fold more enrichment of sterols and sterol esters than the original oil levels were isolated. Nutritional studies of the various fractions are being conducted.

Pollution

Influence of feeding system on the composition of excreta. The results of some 400 individual digestibility trials with lactating cows have been summarized in an attempt to provide a more accurate estimate of the amount of feces and urine voided by cows fed rations consisting of either hay-concentrate or silage-concentrate. The average feces

yields were 20.8 and 31.4 kg/100 kg of metabolic body weight for cows on the hay and silage feeding systems. Hay feeding regimes resulted in a fecal dry matter of 19.2% compared with 15.9% for silage. The proportion of urine in total excreta voided was 39.8% for hay compared with 28.0% for silage feeding systems. In both feeding systems, the amount of feces decreased approximately 20% and the percentage of fecal N increased from 1.90 to 2.10 as the digestibility of the ration increased from 60% to 70%.

Bacteriological content of liquid manure. In the Bacteriological Laboratories of Environment Canada, standard bacterial pollution indicators—coliforms, fecal coliforms (FC), and fecal streptococci (FS)—and heterotrophic bacteria (Standard Plate counts, 20°C and 35°C) have been determined in rectal samples of feces from cows and sheep and at various stages of the liquid-manure storage system operative at the Institute's Greenbelt Farm. All test parameters of animal feces increased significantly immediately after excretion, when FC:FS usually exceeded 4.0. During extended periods of tank storage the trend reversed, and a marked reduction in index bacterial numbers occurred.

TRACE ELEMENTS AND PESTICIDES

Pesticide Residues and Metabolism

The metabolism of methoxychlor in laying hens is being studied with the use of ring-labeled ^{14}C -methoxychlor. Hens fed a low total dose of approximately 0.1 ppm of labeled methoxychlor produced eggs in which no radioactivity could be detected, whereas the excreta were found to contain 80% of the radioactivity. Radioactivity was separated into four fractions by solvent extraction. In order to increase the level of metabolites in eggs for identification purposes, the experiment was repeated with hens fed a diet containing 100 ppm methoxychlor in addition to the labeled methoxychlor. Metabolites have been extracted by solvents, but they have not yet been identified.

Studies on the metabolism of atrazine in laying hens that had been fed 100 ppm atrazine in their diet were continued. Neither atrazine nor hydroxyatrazine was detected in eggs, but both were identified in excreta. Two

other metabolites that had been detected previously in eggs from control hens fed standard rations and in eggs and excreta from treated hens were further investigated. The gas chromatographic retention times of these two metabolites appeared to be identical with those of two metabolites produced from atrazine after hydrolysis with sulfuric acid. More recent findings with different column packings indicated the presence of metabolites in eggs and excreta with retention times similar to those of the dealkylated metabolites *des*-ethylatrazine and *des*-isopropylatrazine. Also, mass spectrometric data indicated the presence of 2,4-dichloro-6-isopropylamino-*s*-triazine, which could be a contaminant formed during the commercial production of atrazine. The identity of the metabolites is being investigated further.

Nutritional Muscular Dystrophy

Selenium and vitamin E included in the mineral mix fed to cows and ewes during pregnancy, for prevention of nutritional muscular dystrophy (NMD) in their offspring, did not result in abnormal selenium concentration in the blood and milk of the dams, or in the blood and tissues of the calves and lambs from birth to 5 wk of age. The results indicate that the use of selenized minerals in preventing NMD in ruminants should be considered.

Metabolism of α -Tocopherol in Ruminants

Studies were conducted on the effect of passage of vitamin E through various parts of the gastrointestinal tract of mature sheep on the destruction and availability of the vitamin. Higher levels of vitamin E were found in the plasma and tissues of sheep after intraduodenal dosing than after intraruminal or intra-abomasal dosing. No differences were observed between intraruminal or intra-abomasal dosing, indicating that the destruction of vitamin E probably occurs in the abomasum.

Selenium Deficiency in Farm Animals

The selenium-deficiency conditions of muscular dystrophy (MD) and exudative diathesis (ED) were produced in chicks, and MD was produced in lambs and beef calves. Higher erythrocyte glutathione peroxidase activity was found in the control animals that were given selenium supplements than in the

selenium-deficient animals: lambs were 12% higher; calves 19%; and chicks with MD 16%, and with ED 14%. The differences were not statistically significant because of wide variability for animals within groups. Although glutathione peroxidase activity in erythrocytes tends to be lower in selenium-deficient farm animals, it cannot be used for

diagnosing selenium deficiency because there is a large and variable nonenzymatic oxidation of NADPH in the assay, and the increase in enzyme activity due to selenium supplementation is small because very little selenium is required to prevent the deficiencies.

PUBLICATIONS

Research

Atwal, A. S., and Sauer, F. 1973. An in vitro study of control mechanisms of gluconeogenesis in beef liver. *Int. J. Biochem.* 4:283-292.

Erfle, J. D. 1973. Acetyl-CoA and propionyl-CoA carboxylation by *Mycobacterium Phei*. Partial purification and some properties of the enzyme. *Biochem. Biophys. Acta* 316:143-155.

Fisher, L. J., Erfle, J. D., Lodge, G. A., and Sauer, F. D. 1973. Effect on propylene glycol or glycerol supplementation of the diet of dairy cows on feed intake, milk yield and composition and incidence of ketosis. *Can. J. Anim. Sci.* 53:289-296.

Foster, T. S. 1973. Evaluation of the possible estrogenic activity of methoxychlor in the chicken by means of feeding trials. *Bull. Environ. Contam. Toxicol.* 9:234-242.

Friend, D. W. 1973. Influence of dietary amino acids on the age of puberty of Yorkshire gilts. *Can. J. Anim. Sci.* 53:701-707.

Friend, D. W. 1973. Self-selection of feeds and water by unbred gilts. *Can. J. Anim. Sci.* 53:1137-1141.

Gowe, R. S., Lentz, W. E., and Strain, J. H. 1973. Long-term selection for egg production in several strains of white leghorns: performance of selected and control strains including genetic parameters of two control strains. 4th Eur. Poult. Conf., London. pp. 225-245.

Heaney, D. P. 1973. Effects of the degree of selective feeding allowed on forage voluntary intake and digestibility assay results using sheep. *Can. J. Anim. Sci.* 53:431-438.

Heaney, D. P., Bender, F., and Lister, E. E. 1973. The use of steamed aspen poplar in a finishing ration for Holstein steers. *Can. J. Anim. Sci.* 53:739-740.

Hickman, C. G. 1973. Herd level methods for age adjustment of milk yields. *J. Dairy Sci.* 56:947-951.

Hidiroglou, M., and Jenkins, K. J. 1973. Le sort du radiosélénium administré dans le rumen ou la caillette du mouton. *Ann. Biol. Anim. Biochim. Biophys.* 12:599-616.

Hidiroglou, M., and Jenkins, K. J. 1973. Absorption of ⁷⁵Se-selenomethionine from the rumen of sheep. *Can. J. Anim. Sci.* 53:345-347.

Hidiroglou, M., and Jenkins, K. J. 1973. Fate of ⁷⁵Se-selenomethionine in the gastrointestinal tract of sheep. *Can. J. Anim. Sci.* 53:527-536.

Hidiroglou, M., Jenkins, K. J., and MacKay, R. R. 1973. Fatty acid composition of blood serum and liver in beef calves as influenced by maternal diet and incidence of nutritional muscular dystrophy. *Can. J. Anim. Sci.* 53:297-305.

Hidiroglou, M., Jenkins, K. J., Wauthy, J. M., and Proulx, J. E. 1973. Changes in plasma and milk tocopherol levels in beef cattle turned out to pasture. *Anim. Prod.* 16:179-183.

Hollands, K. G., and Merritt, E. S. 1973. Blood pressure and its genetic variation and covariation with certain economic traits in egg type chickens. *Poult. Sci.* 52:1722-1728.

Jenkins, K. J., and Winter, K. A. 1973. Effects of selenium supplementation of naturally high selenium swine rations on tissue levels of the element. *Can. J. Anim. Sci.* 53:561-567.

Kramer, J. K. G. 1973. Changes in liver lipid composition of male rats fed rapeseed oil diets. *Lipids* 8:641-648.

Kramer, J. K. G., Mahadevan, S., Hunt, J. R., Sauer, F. D., Corner, A. H., and Charlton, K. M. 1973. Growth rate, lipid composition, metabolism and myocardial lesions of rats fed rapeseed oils (*Brassica campestris* var. Arlo, Echo and Span, and *B. napus* var. Oro). *J. Nutr.* 103:1696-1708.

Lister, E. E., Fisher, L. J., Jordan, W. A., Wauthy, J. M., Comeau, J. E., and Proulx, J. 1973. Influence of shelter, level of feeding, and method of forage conservation on packed cell

- volume and plasma metabolite levels in pregnant beef cows. *Can. J. Anim. Sci.* 53:81-88.
- Lister, E. E., and Lodge, G. A. 1973. Effects of increasing the energy value of a whole milk diet for calves. II. Growth, feed utilization and health. *Can. J. Anim. Sci.* 53:317-325.
- Lodge, G. A. 1973. Improving the nutrient composition of meat producing animals. Pages 215-230 in M. Rechcigl, ed. *Man, food and nutrition*. CRC Press, Cleveland.
- Lodge, G. A., and Heaney, D. P. 1973. Composition of weight change in the pregnant ewe. *Can. J. Anim. Sci.* 53:95-105.
- Lodge, G. A., and Heaney, D. P. 1973. The energy cost of pregnancy in single and twin-bearing ewes. *Can. J. Anim. Sci.* 53:479-489.
- Lodge, G. A., and Lister, E. E. 1973. Effects of increasing the energy value of a whole milk diet for calves. I. Nutrient digestibility and nitrogen retention. *Can. J. Anim. Sci.* 53:307-316.
- Mahadevan, S., Malaiyandi, M., Erfle, J. D., and Sauer, F. 1973. An evaluation of the chemical identity of acyl carnitine esters of hexadecanoic acids. *Biochim. Biophys. Acta* 296:234-340.
- Nagai, J. 1973. Factors affecting a measure of milk production in mice. *Can. J. Genet. Cytol.* 15:660-661.
- Robertson, H. A., and Smeaton, T. C. 1973. The concentration of unconjugated oestrone, oestradiol-17 α and oestradiol-17 β in the plasma of the ewe in relation to the initiation of parturition and lactation. *J. Reprod. Fertil.* 35:761-768.
- Sarda, I. R., Robertson, H. A., and Smeaton, T. C. 1973. Sequential changes in plasma progesterone levels in the ewe during the estrous cycle, and during pregnancy in intact and ovariectomised sheep. *Can. J. Anim. Sci.* 53:25-34.
- Sarkar, N. K. 1973. Characteristics of chicken liver post-mitochondrial preparation after gel filtration in cell-free amino acid incorporating systems. *Int. J. Biochem.* 4:521-530.
- Sarkar, N. K. 1973. Differences between rats and chickens in response to synthetic glucocorticosteroids. *J. Steroid Biochem.* 4:163-170.
- Sauer, F., Erfle, J. D., and Fisher, L. J. 1973. Propylene glycol and glycerol as a feed additive for lactating dairy cows. *Can. J. Anim. Sci.* 53:265-271.
- Sauer, F., and Mahadevan, S. 1973. Metabolite synthesis by rat liver cells and rat liver mitochondria. *Can. J. Biochem.* 51:1567-1580.
- Spencer, J. L., Grunder, A. A., and Robertson, A. 1973. Titers of precipitins in strains of chickens exposed to Marek's disease. *Avian Pathol.* 2:17-26.
- Thorlacius, S. O., and Lodge, G. A. 1973. Absorption of steam volatile fatty acids from the rumen of the cow as influenced by diet, buffers and pH. *Can. J. Anim. Sci.* 53:279-288.

Miscellaneous

- Emmons, D. B., and Lister, E. E. 1973. Protein quality for calf milk replacers. *Proc. 9th Annu. Guelph Nutr. Conf. for Feed Manuf., Toronto*. Canadian Feed Manufacturers Association, Richmond Hill, Ont. pp. 2-5.
- Fisher, L. J. 1973. Incorporation of manure in livestock feeds. *Canadex* 400.60.
- Hickman, C. G. 1973. Selecting large dairy cows. *Canadex* 410.30.
- Hickman, C. G. 1973. Aims in breeding. *Ont. Milk Prod.* 49(3):13.
- Kelly, P. A., Shiu, R. P. C., Friesen, H. G., and Robertson, H. A. 1973. Placental lactogen levels in several species throughout pregnancy. *Proc. 55th Annu. Meet. Endocr. Soc.* A-233.
- Turnbull, J. E., and Hickman, C. G. 1973. Ventilation of dairy barns with porous ceiling inlet systems. Part I. *Can. Dep. Agric. Eng. Res. Serv., Contrib. No.* 371.

Biosystematics Research Institute

Ottawa, Ontario

PROFESSIONAL STAFF

D. F. HARDWICK, B.A., M.Sc., Ph.D.	Director
D. R. OLIVER, B.A., M.A., Ph.D.	Assistant Director
R. ROY	Administrative Officer
M. KHAN (Mrs.), B.Sc., M.L.S.	Librarian, Botany
N. B. SUSSMANN (Mrs.), B.A., M.L.S.	Librarian, Entomology
J. E. H. MARTIN	Head, National Identification Service

Cultivated Crops

B. R. BAUM, M.Sc., Ph.D.	Head of Section; <i>Tamarix</i> , Aveneae
W. G. DORE, B.A., M.Sc., Ph.D.	Gramineae, <i>Bromus</i>
R. J. MOORE, B.A., M.A., Ph.D.	<i>Buddleia</i> , <i>Caragana</i> , <i>Medicago</i>
E. SMALL, B.A., B.Sc., M.Sc., Ph.D.	<i>Cannabis</i> , <i>Daucus</i>

Noxious and Native Plants

G. A. MULLIGAN, B.Sc.	Head of Section; Weeds, Cruciferae
I. J. BASSETT, B.A.	Anemophilous groups, palynology
B. BOIVIN, L.Sc., B.A., Ph.D., F.R.S.C.	Canadian flora
W. J. CODY, B.A.	Curator of Vascular Plant Herbarium; Flora of continental Northwest Territories, ferns
J. McNEILL, B.Sc., Ph.D.	Weeds, Caryophyllaceae

Aquatic Biology, Hemiptera, and Nematology

D. R. OLIVER, B.A., M.A., Ph.D.	Head of Section; Diptera: Chironomidae
R. V. ANDERSON, B.A., M.S., Ph.D.	Nematoda: Hoplolaimidae, Tylenchorhynchidae, Aphelenchoidea

K. G. A. HAMILTON, B.S.A., M.Sc., Ph.D.

L. A. KELTON, B.S.A., M.Sc., Ph.D.

R. H. MULVEY, B.Sc., M.S.

W. R. RICHARDS, B.Sc., M.Sc., Ph.D.

L.-Y. WU (Miss), B.S., M.S., Ph.D.

Homoptera: Cicadellidae

Hemiptera: Corixidae

Hemiptera: Miridae, Anthocoridae

Nematoda: Heteroderidae,
Tylenchidae

Homoptera: Aphidoidea,
Coccoidea, Psyllidae

Collembola, Psocoptera,
Thysanoptera

Nematoda: Criconematidae,
Paratylenchidae

Coleoptera, Siphonaptera, and Arachnida

D. E. BRIGHT, B.S., M.S., Ph.D.

E. C. BECKER, B.S., M.S., Ph.D.

J. M. CAMPBELL, B.S., M.S., Ph.D.

C. D. DONDALE, B.Sc., M.Sc., Ph.D.

G. P. HOLLAND, B.A., M.A., D.Sc., F.R.S.C.

E. E. LINDQUIST, B.S., M.S., Ph.D.

A. SMETANA, M.U.Dr., Cand. Sc. biol.

Head of Section; Coleoptera:
Scolytidae

Coleoptera: Elateridae

Coleoptera: Staphylinidae,
Alleculidae

Arachnida: Araneida, Opiliones

Siphonaptera

Arachnida: Acarina

Coleoptera: aquatic families,
Staphylinidae

Diptera

J. F. MCALPINE, B.S.A., M.Sc., Ph.D.

J. A. DOWNES, B.Sc.

B. V. PETERSON, B.S., M.S., Ph.D.

G. E. SHEWELL, B.Sc., M.Sc.

H. J. TESKEY, B.Sc., M.S.A., Ph.D.

J. R. VOCKEROTH, B.A., M.A., D.Phil.

D. M. WOOD, B.A., M.A., Ph.D.

Head of Section: Lonchaeidae,
Chamaemyiidae

Ceratopogonidae

Simuliidae, Nycteribiidae

Lauxaniidae, Calliphoridae

Tabanidae, Diptera larvae

Syrphidae, Scatophagidae

Tachinidae, Culicidae

Experimental Taxonomy

E. H. SALKELD (Miss), B.S.A., M.S.A., Ph.D.

J. W. ARNOLD, B.A., M.Sc., Ph.D.

J. R. BYERS, B.S.A., M.Sc., Ph.D.

C. F. HINKS, B.Sc., Ph.D.

B. N. A. HUDSON (Miss), B.Sc., Ph.D.

R. MATSUDA, B.A., Ph.D., D.Sc.

Head of Section: Physiology,
histochemistry

Hematology, morphology

Physiology, electron microscopy

Physiology, endocrinology

Physiology, chemotaxonomy

Morphology, systematics of
Hemiptera

Hymenoptera

L. MASNER, B.Sc., M.Sc., Ph.D.	Head of Section; Proctotrupoidea, Bethyloidea, Evanioidea, Sphecoidea
J. R. BARRON, B.Sc., M.Sc., Ph.D.	Ichneumonidae, Braconidae; Trogostidae
C. C. LOAN, B.A., M.S., Ph.D.	Ichneumonidae, Braconidae; Euphorinae
W. R. M. MASON, B.Sc., Ph.D.	Braconidae
O. PECK, ¹ B.Sc., M.Sc., Ph.D.	Chalcidoidea
G. S. WALLEY, ¹ B.S.A., M.S.	Ichneumonidae
C. M. YOSHIMOTO, ² B.A., M.Sc., Ph.D.	Chalcidoidea, Cynipoidea

Lepidoptera and Trichoptera

W. C. MCGUFFIN, ² B.A., M.A., Ph.D.	Head of Section; Lepidoptera: Geometridae
S. A. ALLYSON (Miss), B.Sc.	Lepidoptera: larvae
J. D. LAFONTAINE, B.A.	Lepidoptera: Noctuidae
E. G. MUNROE, B.Sc., M.Sc., Ph.D., F.R.S.C.	Lepidoptera: Pyralidae
A. MUTUURA, B.Sc., Ph.D.	Lepidoptera: Pyralidae
F. SCHMID, Lic. ès. Sc. Nat., D. ès Sc. Nat.	Trichoptera

Mycology

R. A. SHOEMAKER, B.S.A., M.S.A., Ph.D.	Head of Section; Pyrenomycetes
R. ARNOLD (Mrs.), B.A., M.Sc.	Pyrenomycetes on woody plants
D. J. S. BARR, B.Sc., M.Sc., Ph.D.	Phycomycetes
M. P. CORLETT, B.A., M.A., Ph.D.	Pyrenomycetes
M. E. ELLIOTT (Miss), B.A.	Discomycetes
J. H. GINNS, B.S., M.S., Ph.D.	Wood-inhabiting Hymenomycetes
S. J. HUGHES, B.Sc., M.Sc., D.Sc., F.L.S.	Fungi Imperfecti, Hyphomycetes
D. W. MALLOCH, B.A., M.A., Ph.D.	Agaricales
J. A. PARMELEE, B.Sc., M.A., Ph.D.	Curator of Mycological Herbarium; Uredinales and other parasitic fungi
K. A. PIROZYNSKI, B.Sc., M.Sc., D.P.P., Ph.D.	Pyrenomycetes including Fungi Imperfecti
D. B. O. SAVILE, B.S.A., M.Sc., Ph.D., F.R.S.C.	Uredinales
L. K. WERESUB (Miss), B.A., M.A., Ph.D.	Thelephoraceae and Hydnaceae

Departures

H. E. MILLIRON, B.S., M.S., Ph.D. Retired September 1973	Apoidea, Symphyta, Chrysididae
T. MOSQUIN, B.Sc., Ph.D. Resigned March 1973	Reproductive biology of vascular plants
A. WILKES, B.S.A., M.Sc., Ph.D. Retired December 1973	Genetics

VISITING SCIENTISTS

G. A. BRADLEY, B.S.A., M.S., Ph.D.
Environment Canada

Hymenopterous parasites

National Research Council postdoctorate fellows

R. ELLIS, B.Sc., M.Sc., Ph.D., 1973-74
I. SMITH, B.Sc., Ph.D., 1973

Diptera: Culicidae
Taxonomy of water mites (Acari)

¹Honorary Research Associate.

²Seconded from Environment Canada.

INTRODUCTION

In August of 1973, the former Entomology Research Institute was amalgamated with the Mycology Section and the Vascular Plant Section of the former Plant Research Institute to form the new Biosystematics Research Institute. All the taxonomic, floristic, and faunistic research of the Research Branch has thus been combined in a single establishment.

The Biosystematics Research Institute provides a National Identification Service for Canada on fungi, vascular plants, insects, arachnids, and nematodes. To meet this responsibility, the Institute conducts research on various aspects of biosystematics and maintains custody of the National Mycological Herbarium, the Agriculture Canada Vascular Plant Herbarium, and the Canadian National Collections of Insects, Arachnids, and Nematodes.

Subsequent to the formation of the new Institute, the Vascular Plant Taxonomy Section was reorganized into two new sections. One, the Cultivated Crops Section, will specialize in the taxonomy of cultivated plants, whereas the other, the Noxious and Native Plants Section, will specialize in the taxonomy of weeds and other plants detrimental to man.

Reprints of research publications are available from the authors. Correspondence should be addressed to Director, Biosystematics Research Institute, Research Branch, Canada Agriculture, Ottawa, Ont. K1A 0C6.

D. F. Hardwick
Director

THE NATIONAL IDENTIFICATION SERVICE

As a result of reorganization within the Research Branch, the newly formed Biosystematics Research Institute has been able to integrate the identification services provided by the former Entomology Research Institute and the former Plant Research Institute. During the year, 1,475 shipments of material containing more than 261,000 specimens were received for identification. The amount of material received from the Department of Agriculture increased by almost 50% over last year; the 412 shipments that were received comprised 34,510 specimens (13% of the total submissions). The Department of the Environment submitted 159 shipments comprising 158,534 specimens (67%). Of these, 146,540 specimens were arthropods and nematodes from the Mackenzie River Pipeline Survey. Canadian universities continued to make use of the service by submitting 188 shipments comprising 28,013 specimens (11%). Several thousand specimens were received from amateurs and private individuals, and material of medical importance was received from hospitals and health units. More than 182,500 specimens of nematodes, arthropods, plants, and fungi were identified and returned. The accumulation of insect material is largely from the

Mackenzie River Pipeline Survey and will be identified in due course. The accompanying tables show the number of specimens identified, their various sources, and the distribution within the group.

Number of vascular plants identified during 1973

Agriculture Canada	1,110
Environment Canada	617
Other federal departments	233
Provincial departments	381
Industry	9
Universities	1,534
Private inquiries	406
United States	0
Other countries	110
Total identifications for 1973	4,400*

*The figures refer to the number of sheets of botanical specimens identified. The number of specimens per sheet varies from one to fifteen.

*The term collection is used to designate a sample of a fungus population. The sample consists of an indefinite number of individuals, ranging from a few in larger fungi, to several thousands in microfungi. The term collection is used in contradistinction to specimen, which in zoology and phanerogamic botany is the equivalent of an individual. The term culture denotes a living fungus population aseptically cultivated on various substrata under a variety of conditions usually to obtain identifiable structures or different states in the life cycle.

Number of zoological specimens identified during 1973

	Coleoptera	Diptera	Hemiptera	Homoptera	Hymenoptera	Lepidoptera	Siphonoptera	Other insects	Acarina	Other arthropods	Araneida	Nematoda	Total
Canada													
Agriculture Canada	1,529	1,965	524	1,514	1,708	1,316	13	309	416	13	1,926	7,350	18,583
Environment Canada	1,019	52,082	151	2,331	5,465	257	8	31,361	61	14	103	2,181	95,033
Other federal departments	34	585	8	45	—	19	—	77	33	—	—	—	801
Provincial departments	381	242	2	359	73	127	336	16	12	2	—	18	1,568
Industry	8	1	1	6	—	2	—	8	—	—	—	—	26
Universities	857	2,644	399	314	1,005	292	—	291	435	22	679	14	6,952
Private inquiries	2,277	429	25	250	181	710	100	351	167	58	11	1	4,560
United States													
Government departments	332	31	573	—	505	653	206	—	87	—	30	—	2,417
Universities	1,356	1,775	22	—	85	281	—	—	201	—	29	—	3,749
Private inquiries	279	—	—	—	—	32	—	—	1	—	—	—	312
Industry	—	—	—	—	—	—	—	—	—	—	—	—	—
Other countries	653	239	—	1,138	192	21	15	—	148	—	—	—	2,406
Total	8,725	59,993	1,705	5,957	9,214	3,710	678	32,413	1,561	109	2,778	9,564	136,407

RESEARCH

Cultivated Crops

The Cultivated Crops Section is a new section in the Institute, resulting from the recent reorganization. In addition to taxonomic studies on *Avena*, which continue, three new activities have been initiated; these will be integrated with ongoing breeding programs and agronomic studies. The new activities will be directed to the taxonomy of alfalfa (*Medicago*), brome grass (*Bromus*), and carrots (*Daucus*).

Oats. A visit to major European herbaria has permitted the detection, examination, and elucidation of hundreds of types of *Avena* names for nomenclatural aspects of the taxonomy of oats. A new species of *Avena* was discovered in South Morocco from a 120-yr-old collection, and efforts are being made to obtain live material from the site for cytogenetic investigations and related biosystematic work.

Range grasses. Taxonomic studies were conducted on wood millet (*Milium*), *Panicum*, and manna grass (*Glyceria*) in Canada. *Glyceria maxima*, one of 14 species studied, has the greatest productivity and palatability and its distribution and habitat requirements should be explored more fully for its use as a range grass.

Cleavers. Investigation of cleavers (*Galium* species), which are weedy in the grain and rape fields of the Prairie Provinces, reveals that two species occur: *G. spurium* L., an introduction from Europe, and *G. aparine* L., a native and introduced species. *Galium spurium* is the more serious weed and is the species found in rape fields. These plants have usually been classed as a single species (*G. aparine*), but two distinct species should be recognized.

Cannabis. Analysis of variation in 232 populations of *Cannabis* by numerical taxonomic techniques indicated that the genus is best treated as monotypic, and that previously recognized species, other than *C. sativa* L., do not merit recognition. Analysis by multivariate methods indicated that wild specimens can almost invariably be distinguished from cultigens by seed characteristics; and that morphology is not useful for distinguishing "drug strains" from "fiber strains."

Noxious and Native Plants

Weed biology. The floral characteristics most important in the long-distance attraction of pollinating insects to the blossoms of weeds are apparently the color and brightness of flowers, the size of the flower target, and the odor of the flowers. Weed flowers that are occasionally or frequently visited by insects tend to have a higher reflectance in ultraviolet and in blue than do flowers that are rarely visited. The flowers most visited generally have flower targets over 20 mm in diam, or flowers that are odoriferous, or both. None of these characteristics appear to be of prime importance in determining the kinds of insects that visit the flowers of weeds. The flowers or flower heads of many weeds have an outer portion that reflects ultraviolet or blue wavelengths, or both, and a central portion that absorbs these wavelengths. These flower characteristics, and information on life duration, breeding systems, and pollen vectors, are useful in evaluating the different strategies that enable a rapid buildup of large populations in constantly disturbed habitats. A simple gray scale for measuring reflectance and color in the insect and human visual spectra was developed.

Weed taxonomy. A manuscript for a new color-illustrated bilingual publication on the common weeds of Canada was submitted for publication. Descriptions, photographs, and summaries of abundance and distribution of pollen and fungus spores were prepared for 169 Canadian species that cause respiratory allergies.

A survey of the pollen morphology of a representative sample of the four subgenera of *Minuartia* (Caryophyllaceae) has revealed that in one of these subgenera the pollen is trizonocolpate, a condition otherwise unknown in the subfamily Alsinoideae, to which *Minuartia* belongs.

Other activities. The confused chromosome number situation in *Sanguisorba canadensis* L. was clarified. Checksheets and reports for 10 sites in the District of Mackenzie, examined during the summer of 1972 for the International Biological Program (IBP/CT Panel 10), were completed and submitted to the Panel. Work on the first volume of a comprehensive flora of Canada was started. On the basis of pollen morphology, an identification key has been provided for 45

North American species of *Trifolium*. The Index Seminum, first issued by the Department in 1938, was discontinued at the end of 1973.

A numerical taxonomic study of the Portulacaceae subfamily Montioideae has been completed and establishes the generic limits of *Claytonia*. In association with this, the value of space-dilating strategies in numerical classification above the species level is demonstrated.

Aquatic Biology, Hemiptera, and Nematology

Aquatic insects. An investigation of the host specificity of water-mite larvae on chironomid adults was started. Preliminary results indicate that the adaptive radiation of some water-mite groups is related to certain chironomid lineages.

Hemiptera. Analyses and descriptions were completed for the 35 species included in a handbook on the *Lygus* bugs of North America. Keys to subfamilies, genera, and species have been completed for handbooks on prairie Miridae and Canadian Anthocoridae. Illustrations are being prepared for the 183 genera to be treated in a manual of the genera of Aphidoidea in Canada. Analyses of the generic limits and revisions for the nearctic species of the leafhopper tribes Macropsini and Aphrodini are well advanced. This includes special reference to the host preference and host specificity of species of *Oncopsis*. Generic reviews have been completed for the leafhopper genera *Rosenus*, *Palus*, *Paraphlepsius*, *Pendarus*, and *Amblysellus*. A review of the world fauna of the beech-inhabiting aphid genus *Phyllaphis* was completed. It is concluded that a new species is restrictively associated with the North American beech, *Fagus grandifolia* Ehrh.

Nematology. An illustrated key being prepared for the Canadian species of spiral nematodes (*Helicotylenchus*) includes their distribution and descriptions of four new species. Studies on the distribution of the grass cyst nematode (*Heterodera*) in Canada and the description of a new, closely related species are nearly completed. Completed ultrastructural studies on the esophagus of a stylet nematode (*Tylenchorhynchus*) emphasizes new structural features of the corpus, metacarpus, glands, and esophagointestinal valve. Most significant was the finding of a

valvular apparatus at the dorsal duct terminus, which regulates emission of gland secretions during feeding. Application of the scanning electron microscope in comparative studies of the cyst nematodes has provided new data on the characteristics and associations of perineal tubercles and vulval bodies, thus facilitating identification of species.

Collaboration with other agencies. Supervision of the revision of the genus *Orthocladus* by a graduate student (A. Sponis) at Carleton University continued. Cooperative taxonomic studies include aquatic insects and nematodes of the Mackenzie River system with Environment Canada; the root-knot nematode with the Research Station at Harrow; and the root-lesion nematodes with the Research Station at Vineland Station. A display of the insects and nematodes occurring in the National Capital Area is being prepared for the National Museum.

Coleoptera, Siphonaptera, and Arachnida

Handbooks. A handbook entitled *The Scolytidae of Canada and Alaska* has been submitted for publication; 213 species in 44 genera are treated. Substantial progress was made on the illustrations and distributional data for a handbook of the fleas of Canada, Alaska, and Greenland. A provisional key to the families of spiders of Canada has been completed.

Arachnida. The preliminary research on the spider genera *Philodromus* and *Apollophanes* has been completed and a revision of the species in *Oxyptila* is ready for publication. A review of the taxonomic characters used to classify genera of Tarsonemidae has been broadened into a full-scale review of generic and family-level concepts in the Tarsonemidae from a world standpoint. The results of a study of the relationships between mites and other arthropods in forest floor habitats were presented at the Third Soil Microcommunity Conference at Syracuse, New York.

Coleoptera. The 200 or more species of the bark beetle genus *Pityophthorus* have been arranged in species groups and a key for distinguishing the groups has been devised; description of the species and the accumulation of distributional data is continuing. Substantial progress has been made on a revision of the staphylinid subfamily Tachyporinae, with about half the genera revised.

Research has been completed on a revision of the 16 eastern North American species in the elaterid genus *Athous*; two new species are described and several new synonyms are discussed. Preparatory work on a revision of the hydrophilid subfamily Sphaeridiinae of North America has begun; 10 genera and about 90 species will eventually be treated.

Collaboration with other agencies. The postdoctorate program of Mr. J. Robillard, who is specializing in acarology at Carleton University, is being supervised by an Institute scientist.

Diptera

Handbooks. Satisfactory progress was made on *The Manual of the Genera of North American Diptera*, scheduled for completion in 1975. A handbook on the mosquitoes of Canada was about half completed. Another handbook on immature stages of tree-inhabiting Diptera was drafted. Similar treatments of blood-sucking Ceratopogonidae, aphid-killing Syrphidae, Chamaemyiid predators of Adelgidae, and the blow flies of Canada were advanced.

Biting flies. Work continued on separate revisions of the black fly genera *Simulium*, *Cnephia*, *Prosimulium*, and *Eusimulium*, and a taxonomic treatment of the black flies of Iceland was about half completed. Descriptions were prepared for larvae of many horse flies; these were collected in British Columbia and rearing of adults is in progress.

Parasites and predators. Five papers on Syrphidae were completed. Field work was completed for the tachinid fauna (50 species) of northern Canada and descriptions were prepared for six species; papers were completed on the genera *Masistylum* and *Allophorocera*; and progress was made on revisions of *Periscepsia*, *Macquartia*, and *Palpexorista* (parasites of forest Lepidoptera). Descriptions were written for a number of new genera and species of chamaemyiid predators of aphids.

Biosystematics. A comprehensive project on feeding and mating behavior of insectivorous Ceratopogonidae in relation to classification was completed. A paper on the feeding habits of adult Chironomidae was finalized, and two papers dealing with the feeding habits and the origin of the non-bloodsucking habit in primitive Diptera, moths, and other insects were presented at

the First International Congress of Systematic and Evolutionary Biology, Boulder, Colo.

Biochemical and cytotaxonomic investigations were carried out on 35 species of horse flies. Some progress was made on host-parasite relationships between species complexes of cutworms (*Euxoa* spp.) and tachinids (*Gonia* spp.).

Other research on Diptera. About 15,000 pieces of Canadian amber of Cretaceous age were collected; some 12,000 pieces were processed, yielding 470 fossil insects. A fossil ironomyiid, a rare family now known only from Australia, was described. Analysis and descriptions of about 100 fossil Ceratopogonidae continued. A paper on the morphology, function, and phylogenetic significance of larval mouthparts of culicine Diptera was completed.

Experimental Taxonomy

Biosystematics of Euxoa. The program concentrated on hybridization experiments among three populations of *E. campestris* and two populations of *E. declarata*, all of which had been collected in various locations in Saskatchewan during August 1971. Mating occurred in all 12 combinations and fertile eggs were obtained in eight. *E. declarata* males mated more successfully with *E. campestris* females than vice versa. Indeed, more fertile eggs were obtained from these crossings than were obtained from either of the parent stocks when inbred, and the larvae and adults were larger and more vigorous. However, each hybrid that has been reared to date has exhibited a marked sexual desynchronization of emergence. Pinned series of the parent stocks and the hybrid progeny have been made for analysis of the genitalic characters. Electrophoretic analysis of proteins and certain enzyme systems from adults and eggs of parents and progeny are being performed. The external morphology of the eggs of some 30 *Euxoa* species has been examined.

Biosystematics of Tabanidae. Esterase patterns of flies of several species in the subfamily Tabaninae are rather similar but do differ in certain areas from those in the Chrysopsinae. However, data to date suggest that esterase patterns reflect the habitat so that species from two genera that occur in a single habitat have a greater similarity in their esterase patterns than do two species from

the same genus that occur in different habitats.

New structures and functions. A great diversity in the pattern of microsculpturing and in the form of the structural units within the pattern has been found on the cuticle of Lepidoptera larvae. The pattern appears to be constant within a species and has been found to be a useful character for distinguishing between some species of *Euxoa*, but not others. The biological significance of these patterns in terms of reflective properties and the enhancing of cryptic or acryptic properties of the larvae has been examined.

Cuticular structures that can be used to easily and reliably sex the penultimate and ultimate instars of noctuid larvae were found and described. Earlier instars can also be sexed, but with somewhat more difficulty. The ability to determine the sex of larvae has proved to be of much value in behavioral, biochemical, and cytogenetic studies.

Previously undescribed peripheral neurosecretory cells associated with the dorsal vessel and the transverse nerves have been found in larvae of several *Euxoa* species. Differences in the number of cells within each neurosecretory cell mass are being examined for species specificity. Morphological distinctions, sufficient to distinguish between species in some cases, have been found in the hemocytes from 24 species of noctuid larvae.

Hymenoptera

Parasitic wasps. Thirty-one new North American and one European species of the braconid genera *Leiophron* Nees and *Peristenus* Foerster, parasitic on plant bugs of the family Miridae, were described and details on biology, and on collecting and rearing methods, were obtained. Two economic species of the braconid genus *Microctonus* Wesmael, parasitic on weevils, were described, one from Britain and one from Argentina. Some species of the braconid genus *Meteorus* were transferred to *Zemiotes*, tribe Zelini. A new subgenus and two Nearctic species of the chalcid genus *Derostenus* Westwood were described. The North American species of *Chrysocharis* Foerster were reviewed; two subgenera were recognized, *Kratochviliana* with 15 new species, and *Chrysocharis* with 6 new species. A key to and review of approximately 350 genera of Scelionidae and Platygasteridae of the world

is in preparation. A new highly aberrant genus and species of Diapriidae from Brazil was described.

Other groups. Research indicated that large populations of the ant species *Formica obscuripes* Forel have a stabilizing effect on populations of the scale insect *Toumeyella numismaticum* Pettit & McDaniel and its coccinellid predator *Hyperaspis congressis* Watson; large ant populations enable the predator to maintain itself from year to year and provide effective control of the scale population.

Faunistics. A report on studies of wind dispersal of insects in Alaska during 1966 and 1969, based on trapping techniques, was completed.

Collaboration with other agencies. A study of the Provancher types of Ichneumonidae at Université Laval and a history of the collections of Provancher were completed. A study of the Provancher collection of Sphecoidea with a review of the types was undertaken.

Lepidoptera and Trichoptera

Handbooks. Two handbooks were started in 1972, one devoted to the cutworm moths of Ontario and Quebec and the other to the lepidopterous leaf miners of temperate North America. Both works are well advanced.

Part III of the Guide to the Geometridae of Canada is in preparation. This part deals with several pests of economic importance such as the linden looper, *Erranis tiliaria* (Harr.), and the spring cankerworm, *Paleacrita vernata* (Peck).

A list of 50 Canadian species of a caddis fly genus (*Limnephilus*) has been prepared and the distribution of each established.

Faunal monographs. Work continues on the pyralid part of *Moths of America North of Mexico*. The first of two fascicles dealing with the Pyraustinae is in preparation.

Taxonomy. Moths of the pyralid genera *Diaphania*, *Polygrammodes*, and *Anomobia* were studied at the British Museum and other museums. A world revision of these and closely related moths is in preparation. A study is in progress of the larvae of 10 species of the genus *Tetralopha* (Pyralidae).

Studies of the species groups *punctigera*, *terrena*, and *misturata* of the cutworm genus *Euxoa* are nearing completion.

Mycology

Ascomycetes. Light and electron microscopy elucidated the structure of the ascus apex of *Ciboria acerina* Whetzel & Buchwald ex Groves & Elliott of the family Sclerotiniaceae, a large group of seed- and fruit-infecting Discomycetes. The ascus structure is a useful taxonomic character and is functionally important in the forcible discharge and dissemination of infectious ascospores. In cooperation with Dr. G. Ouelette, Canadian Forestry Service (CFS), Sainte-Foy, Que., work was concluded on the reassessment of the genus *Tympanis* in which 38 species were recognized. These are mainly canker organisms of orchards and forests. In a joint study with the CFS at Victoria, and the University of Manitoba, on needle blight organisms of spruce and fir, a new genus and three new species were described. Among the contributions to *Fungi Canadenses* were three species of *Marsonnina* that cause leaf spots of poplars, and a *Pleiochaeta* that is very destructive of lupines in the United States as far north as Alabama; it was recently discovered in Canada. With J. D. Smith, of the Research Station at Saskatoon, work was concluded on 10 brome grass parasites, 5 of which were new records for Canada; only 2 of the 10 had previously been recorded on brome grasses in Saskatchewan. A total of 33 air-borne fungi were identified and illustrated from spore trapplings made over brome grass crops. Work was concluded on type studies of 65 species of *Massaria*. Most of the Canadian *Hypoxylon* species have been collected and studied in pure culture. Illustrated descriptions are in preparation. The canker organism found on Russian olive (*Elaeagnus angustifolia* L.) proved to be *Phomopsis elaeagni* (Carter & Saccamano) Arnold & Carter and was recorded in Canada for the first time. A species of *Botrytis* has been found causing wilting of *Erythronium americanum* Ker in the Ottawa area. Although many *Botrytis* species correlate to *Botryotinia*, no discomycetous state has been found in nature or developed in artificial culture. The last of three seasons of field work for collecting powdery mildews (*Erysiphales*) in Ontario was carried out at Black Sturgeon Lake.

Basidiomycetes: rusts and smuts. A taxonomic-ecogeographic study of rusts (*Puccinia* spp.) on Saxifragaceae, covering 33

rusts and 97 hosts, throws much light on relative age of various genera and sections of the hosts, and occasionally supports the redispotion of anomalously classified species. A comparative study of the grass rusts throws light on the composition and interrelationships of the grass tribes. A cytological investigation of the rust *Roestelia brucensis* Parmelee on juniper showed that this is a true repeating aecial species. The dicaryotic nuclear condition prevails throughout the complete cycle. This condition is known in other rusts, but this is the first demonstration of it in *Roestelia*.

Basidiomycetes, Hymenomycetes. A world monograph was concluded for the genus *Merulius*, including nearly 400 names and incorporating results of natural collections and studies of pure cultures. Cultural characteristics were extremely important in determining species relationships. Serology was used to confirm the distinctions between some morphologically similar species of *Gloeophyllum* and *Fomes*. Genetic data governing compatibility of a number of Hymenomycetes were critically reexamined and some new interpretations given for the basis of compatibility. Additional isolations were made of sclerotium-producing fungi, *Serpula*, *Typhula*, and allies, including the rarely seen naturally formed sclerotia of *Serpula pinastri* (Fr.) W.B. Cooke. Work on mushrooms was concentrated on the preparation of an illustrated manual on lawn mushrooms occurring in Canada, to aid in the identification of the most commonly collected edible and poisonous species.

Fungi Imperfecti. Six species of *Spadicoides* known in Canada were included in the first fascicle of *Fungi Canadenses*. Continued studies on sooty molds confirmed the regular pleomorphy and bring order into a hitherto confused group. A joint project with the University of Waterloo was completed on 11 species of Hyphomycetes referable to *Chalara* and a new genus *Fusichalara*.

Phycomycetes. *Olpidium brassicae* (Wor.) Dang., a zoosporic fungus and vector of several plant virus diseases, has been recovered from the main carrot-growing areas of Ontario and Quebec. There are different strains of this fungus, but no correlation between the virulent "carrot" strain and carrot rusty root disease in Ontario. Zoosporic fungi and *Pythium* species are being

investigated in cooperation with the Ottawa Research Station as possible vectors of wheat spindle streak mosaic, a virus that causes

crop loss in Ontario. Ultrastructural studies on zoospores of four fungi have shown fundamentally different zoospore types.

PUBLICATIONS

Research

Barr, D. J. S. 1973. Six *Rhizophydium* species (Chytridiales) in culture. *Can. J. Bot.* 51:967-975.

Bassett, I. J. 1973. The plantains of Canada. *Can. Dep. Agric. Monogr.* 7. 47 pp.

Bassett, I. J., and Crompton, C. W. 1973. The genus *Atriplex* (Chenopodiaceae) in Canada and Alaska. III. Three hexaploid annuals: *A. subspicata*, *A. gmelinii* and *A. alaskensis*. *Can. J. Bot.* 51:1715-1723.

Baum, B. R. 1972. Material for an international oat register. *Can. Dep. Agric. Publ., Information Canada, Ottawa.* 266 pp.

Baum, B. R. 1973. The concept of relevance in taxonomy with special emphasis on automatic classification. *Taxon* 22:329-332.

Baum, B. R. 1973. The genus *Danthoniastrum*, about its circumscription, past and present status, and some taxonomic principles. *Osterr. Bot. Z.* 122:51-57.

Baum, B. R. 1973. Extrapolation of the predomesticated hexaploid cultivated oats. *Evolution* 27:518-523.

Baum, B. R., and Findlay, J. N. 1973. Preliminary studies in the taxonomy of *Danthonia* in Canada. *Can. J. Bot.* 51:437-450.

Baum, B. R., and Lefkovitch, L. P. 1973. A numerical taxonomic study of phylogenetic and phenetic relationships in some cultivated oats, using known pedigrees. *Syst. Zool.* 22:118-131.

Baum, B. R., Rajhathy, T., and Sampson, D. R. 1973. An important new diploid *Avena* species discovered on the Canary Islands. *Can. J. Bot.* 51:759-762.

Borch, H., and Schmid, F. 1973. On *Ornithoptera priamus caelestis* Rothschild, *demophanes* Fruhstorfer and *boisduvali* Montrouzier (Papilionidae). *J. Lepid. Soc.* 27:196-205.

Botosaneanu, L., et Schmid, F. 1973. Les Trichoptères du Musée d'Histoire naturelle de Genève. *Rev. suisse Zool.* 80:221-256.

Bottimer, L. J. 1973. Two new American bruchids in the *Sordidus* group of *Stator* (Coleoptera: Bruchidae) with notes on other species. *Can. Entomol.* 105:545-551.

Boyes, J. W., and Shewell, G. E. 1973. Cytotaxonomy of Bombyliidae (Diptera). *Can. J. Genet. & Cytol.* 15:21-37.

Bright, D. E. 1973. *Xyleborus howdenae*, new name, and some corrections to "The Scolytidae and Platypodidae of Jamaica". *Coleopt. Bull.* 27:18.

Bright, D. E., and Stark, R. W. 1973. Bark and ambrosia beetles of California (Coleoptera: Scolytidae). *Calif. Insect Surv. Bull.* 16:1-169.

Byers, J. R., and Anderson, R. V. 1973. Morphology and ultrastructure of the intestine in a plant-parasitic nematode, *Tylenchorhynchus dubius*. *J. Nematol.* 5:28-37.

Campbell, J. M. 1973. A revision of the genus *Tachinomorphus* (Coleoptera: Staphylinidae) of North and Central America. *Can. Entomol.* 105:1015-1034.

Campbell, J. M. 1973. New species and records of New World Micropeplinae (Coleoptera: Staphylinidae). *Can. Entomol.* 105:569-576.

Campbell, J. M. 1973. A revision of the genus *Tachinus* (Coleoptera: Staphylinidae) of North and Central America. *Mem. Entomol. Soc. Can.* No. 90. 137 pp.

Campbell, J. M. 1973. A new ecitophilous species of *Ecitoxenia* Wasmann (Coleoptera, Staphylinidae) from Colombia. *Papéis Avulsos Zool.* 27:27-30.

Chong, J., and Barr, D. J. S. 1973. Zoospore development and fine structures in *Phlyctochytrium arcticum* (Chytridiales). *Can. J. Bot.* 51:1411-1420.

Cody, W. J., and Boivin, B. 1973. Purple coneflower, *Echinacea purpurea*, in Ontario. *Can. Field Nat.* 87(1):70.

Corbet, P. S., and Danks, H. V. 1973. Seasonal emergence and activity of mosquitoes (Diptera: Culicidae) in a high-arctic locality. *Can. Entomol.* 105:837-872.

Corlett, M., Hughes, S. J., and Kaufert, M. 1973. New Zealand fungi. 19. Centrum organisation in some Euantennariaceae and Metacapnodiaceae. *N.Z. J. Bot.* 11:213-230.

Corlett, M. 1973. Surface structure of the conidium and conidiophore of *Stemphylium botryosum*. *Can. J. Microbiol.* 19:392-393.

- Danks, H. V., and Corbet, P. S. 1973. Sex ratios at emergence of two species of high-arctic *Aedes* (Diptera: Culicidae). Can. Entomol. 105:647-651.
- Danks, H. V., and Corbet, P. S. 1973. A key to all stages of *Aedes nigripes* and *A. impiger* (Diptera: Culicidae) with a description of first-instar larvae and pupae. Can. Entomol. 105:367-376.
- Dondale, C. D. 1972. Laboratory breeding between European and North American populations of the spider *Philodromus rufus* Walckenaer (Araneida: Thomisidae). Bull. Brit. Arachnol. Soc. 2:49-52.
- Dondale, C. D. 1972. Effects of carbofuran on arthropod populations and crop yield in hayfields. Can. Entomol. 104:1433-1437.
- Dondale, C. D., and Redner, J. H. 1972. A synonym proposed in *Periomones*, a synonym rejected in *Walckenaera*, and a new species described in *Cochlembolus* (Araneida: Erigonidae). Can. Entomol. 104:1643-1647.
- Dondale, C. D., Redner, J. H., and Semple, R. B. 1972. Diel activity periodicities in meadow arthropods. Can. J. Zool. 50:1155-1163.
- Dondale, C. D., and Hegdekar, B. M. 1973. The contact sex pheromone of *Pardosa lapidicina* Emerton (Araneida: Lycosidae). Can. J. Zool. 51:400-401.
- Downes, J. A. 1973. Lepidoptera feeding at puddle-margins, dung, and carrion. J. Lepid. Soc. 27:89-99.
- Dumais, J., Perron, J.-M., and Dondale, C. D. 1973. Éléments du comportement sexuel chez *Pardosa xerampelina* (Keyserling) (Araneida: Lycosidae). Can. J. Zool. 51:265-271.
- Findlay, J. N., and McNeill, J. 1973. IOPB chromosome number reports: XL. Taxon 22:285-291.
- Gillett, J. M., Bassett, I. J., and Crompton, C. W. 1973. Pollen morphology and its relationship to the taxonomy of North America *Trifolium* species. Pollen & Spores 15:91-108.
- Ginns, J. H. 1973. *Coniophora*: study of 22 type specimens. Can. J. Bot. 51:249-259.
- Hardwick, D. F., and Lefkovitch, L. P. 1973. Species separation in the *declarata* group of the genus *Euxoa*, a computer analysis based on structural characters. Can. Entomol. 105:501-508.
- Hardwick, D. F. 1973. A synopsis of the *albipennis-lilloet-declarata* series of the genus *Euxoa* (Lepidoptera: Noctuidae) with descriptions of a new species and a new subspecies. Can. Entomol. 105:493-500.
- Hardwick, D. F. 1973. A new species of *Euxoa* (Lepidoptera: Noctuidae) resembling *Euxoa obeliscoides*. Can. Entomol. 105:75-78.
- Hardwick, D. F. 1973. A new species of *Schinia* (Lepidoptera: Noctuidae) from Steens Mt., Oregon. Can. Entomol. 105:1003-1004.
- Hudson, A. 1973. Biosystematics in the genus *Euxoa* (Lepidoptera: Noctuidae). Can. Entomol. 105:1199-1209.
- Hughes, S. J. 1973. *Antennatula shawiae* n. sp. Trans. Mycol. Soc. India 1:1-4.
- Hughes, S. J., and Nag Raj, T. R. 1973. New Zealand fungi: 20. *Fusichalara* gen. nov. N.Z. J. Bot. 11:661-671.
- Ivanochko, M. 1973. An evaluation of some of the factors that may contribute to proliferation of braconid parasites. Proc. Entomol. Soc. Ont. 102:109-114.
- Kevan, P. G. 1973. Parasitoid wasps as flower visitors in the Canadian High Arctic. Anz. Schaedlingskd. Pflanzenschutz 46(1):3-7.
- Kevan, P. G., Grainger, N. D., Mulligan, G. A., and Robertson, A. R. 1973. A gray-scale for measuring reflectance and color in the insect and human visual spectra. Ecology 54:924-926.
- Lafontaine, J. D. 1973. Eastern North American species of *Antispila* (Lepidoptera: Heliozelidae) feeding on *Nyssa* and *Cornus*. Can. Entomol. 105:991-994.
- Lindquist, E. E. 1973. Observations on the generic classification of Tarsonemid mites (Prostigmata). Pages 293-296 in Proc. 3rd Int. Congr. Acarol., Prague.
- Loan, C. C., and Bilewicz-Pawinska, T. 1973. Systematics and biology of four Polish species of *Peristenus* Foerster (Hymenoptera: Braconidae, Euphorinae). Environ. Entomol. 2:271-278.
- Loan, C. C., Drea, J. J., Dysart, R. J., and Coles, L. W. 1972. *Microctonus stelleri* (Hymenoptera: Braconidae, Euphorinae), a new parasite of the alfalfa weevil introduced into the United States. Can. Entomol. 104:1445-1456.
- Loan, C. C., and Matthews, R. 1973. *Cosmophorus capeki* n. sp. from New York (Hymenoptera: Braconidae: Euphorinae). Proc. Entomol. Soc. Wash. 75:205-208.
- Loan, C. C., and New, T. R. 1972. An account of the North American species of *Euphoriella* Ashmead with descriptions of seven new species (Hymenoptera: Braconidae, Euphorinae). Proc. Entomol. Soc. Ont. 102:92-108.

- Loan, C. C., and Thompson, L. S. 1972. *Pygostolus falcatus* found in Prince Edward Island (Hymenoptera: Braconidae, Blacinae). Can. Entomol. 104:779-780.
- Malloch, D. 1973. Ascospore sculpturing in *Morchella* (Ascomycetes: Pezizales). Can. J. Bot. 51:1519-1520.
- Malloch, D., and Benny, G. L. 1973. California Ascomycetes: Four new species and a new record. Mycologia 65:648-660.
- Malloch, D., and Cain, R. F. 1973. The Trichocomaceae (Ascomycetes): synonyms in recent publications. Can. J. Bot. 51:1647-1648.
- Malloch, D., and Cain, R. F. 1973. The genus *Thielavia*. Mycologia 65:1055-1077.
- McAlpine, J. F. 1973. A fossil ironomyiid fly from Canadian amber (Diptera: Ironomyiidae). Can. Entomol. 105:105-111.
- McGuffin, W. C. 1973. The *Rheumaptera* of North America (Lepidoptera: Geometridae). Can. Entomol. 105:383-398.
- McNeill, J. 1973. *Gypsophila* and *Stellaria*: an unexpected problem in generic delimitation. Notes Roy. Bot. Gard. Edinburgh 32:389-395.
- McNeill, J. 1973. *Lewisia triphylla* (S. Watson) Robinson and *Spraguea umbellata* Torrey, a new species for Canada. Syesis 6:179-181.
- Milliron, H. E. 1973. A monograph of the Western Hemisphere bumblebees (Hymenoptera: Apidae; Bombinae). II. The genus *Megabombus* subgenus *Megabombus*. Mem. Entomol. Soc. Can. No. 89. 237 pp.
- Milliron, H. E. 1973. A monograph of the Western Hemisphere bumblebees (Hymenoptera: Apidae; Bombinae). III. The genus *Pyrobombus*, subgenus *Cullumanobombus*. Mem. Entomol. Soc. Can. No. 91. pp. 239-333.
- Mulligan, G. A. 1973. A clarification of the chromosome number situation in *Sanguisorba canadensis*. Can. J. Bot. 51:2075-2077.
- Mulligan, G. A., and Cody, W. J. 1973. IOPB chromosome number reports: XL. Taxon 22:290-291.
- Mulligan, G. A., and Kevan, P. G. 1973. Color, brightness, and other floral characteristics attracting insects to the blossoms of some Canadian weeds. Can. J. Bot. 51:1939-1952.
- Mulvey, R. H. 1973. Morphology of the terminal areas of white females and cysts of the genus *Heterodera* (s.g. *Globodera*). J. Nematol. 5:303-311.
- Mulvey, R. H. 1973. Nematodes of the family Mononchidae (Dorylaimida: Mononchoidea) from Sable Island, Canada. Can. J. Zool. 51:237-242.
- Munroe, E. 1973. A new genus and species of Odontiinae from Arkansas (Lepidoptera: Pyralidae). Can. Entomol. 105:669-671.
- Munroe, E. 1973. A supposedly cosmopolitan insect: The celery webworm and allies, genus *Nomophila* Hübner (Lepidoptera: Pyralidae: Pyraustinae). Can. Entomol. 105:177-216.
- Munroe, E. 1973. A new species of *Trischistognatha* from Venezuela (Lepidoptera: Pyralidae: Evergestinae). Can. Entomol. 105:1081-1083.
- Munroe, E. 1973. A new genus for *Noctueliopsis radialis* (Lepidoptera: Pyralidae: Odontiinae). Can. Entomol. 105:1361-1362.
- Mutuura, A., and Munroe, E. 1973. American species of *Dioryctria* (Lepidoptera: Pyralidae). IV. The *Schuetzeella* group and the taxonomic status of the spruce cone moth. Can. Entomol. 105:653-668.
- New, T. R., and Loan, C. C. 1972. Records of Psocoptera collected near Belleville, Ontario. Proc. Entomol. Soc. Ont. 102:16-23.
- Ohira, H., and Becker, E. C. 1973. Elateridae (Coleoptera) from the Canadian Nepal Expedition (1967). 2. Descriptions of four new species of *Glyphonyx* and *Parhemiops* with a new record for *Hemiops flava* (Lap. de Cast.). Orient. Insects 6:135-140.
- Ohira, H., and Becker, E. C. 1973. Elateridae (Coleoptera) from the Canadian Nepal Expedition (1967). 3. Descriptions of new species and records of *Dima*, *Penia*, and *Neocsikia* new genus. Orient. Insects 6:531-537.
- Ohira, H., and Becker, E. C. 1973. Elateridae (Coleoptera) from the Canadian Nepal Expedition (1967). 4. Descriptions of new species and records of the subfamilies Negastrinae and Hypnoidinae. Orient. Insects 7:69-77.
- Parmelee, J. A., and Corlett, M. 1973. Development of the aecium and nuclear condition of *Roestelia brucensis*. Rep. Tottori Mycol. Inst. 10:189-201.
- Pirozynski, K. A., and Hodges, C. S., Jr. 1973. New Hyphomycetes from South Carolina. Can. J. Bot. 51:157-173.
- Pirozynski, K. A. 1973. Three hyperparasites of Ascomycetes. Mycologia 35:761-767.
- Richards, W. R. 1973. *Aulacorthum rhusifoliae* (Homoptera: Aphididae), a new poison ivy inhabiting aphid from Ontario. Can. Entomol. 105:173-174.
- Salkeld, E. H. 1973. The chorionic architecture and shell structure of *Amanthes c-nigrum* (Lepidoptera: Noctuidae). Can. Entomol. 105:1-10.
- Savile, D. B. O. 1973. Rusts that pass import inspection. Can. Plant Dis. Surv. 53:105-106.

- Savile, D. B. O. 1973. Fungal spores: their liberation and dispersal. *Mycologia* 65:259-263.
- Savile, D. B. O. 1973. Aeciospore types in *Puccinia* and *Uromyces* attacking Cyperaceae, Juncaceae and Poaceae. Rep. Tottori Mycol. Inst. 10:225-241.
- Savile, D. B. O. 1973. A variety of *Puccinia centaureae* on *Centaurea diffusa*. Can. J. Bot. 51:1077-1078.
- Schmid, F. 1973. Sur quelques sous-espèces d'*Orithoptera victoriae* (Lepidoptera, Papilionidae). II. Can. Entomol. 105:701-708.
- Sewell, R. 1973. Plant-parasitic nematodes from Canada and abroad, 1971. Can. Plant Dis. Surv. 53:34-35.
- Small, E. 1973. Photosynthetic ecology of normal and variegated *Aegopodium podagraria*. Can. J. Bot. 51:1589-1592.
- Small, E., and Beckstead, H. D. 1973. Cannabinoid phenotypes in 350 stocks of *Cannabis*. Lloydia 36:144-165.
- Small, E., and Beckstead, H. D. 1973. Common cannabinoid phenotypes in *Cannabis*. Nature (Lond.) 245:147-148.
- Smetana, A. 1973. A note of the genus *Bohemielina* Mach. (Coleoptera: Staphylinidae). Can. Entomol. 105:351-352.
- Smetana, A. 1973. Eine neue Art der Gattung *Thinobius* Kiesw. aus der slowakei (Col. Staphylinidae). Entomol. Bl. Biol. Syst. Kaefer 69:42-46.
- Smetana, A. 1973. Ueber einige von Dr. M. Bernhauer beschriebene *Gabrieus*-Arten (Coleoptera, Staphylinidae). Nouv. Rev. Entomol. 3:125-136.
- Smetana, A. 1973. Die *Leptusa*-Arten der tschechoslovakischen republik einschließlic Karpatorublands (Col., Staphylinidae). Stuttg. Beitr. Naturked. 255:1-46.
- Vockeroth, J. R. 1973. A review of the world genera of Mydaeinae, with a revision of the species of New Guinea and Oceania (Diptera: Muscidae). Pac. Insects Monogr. 29:1-134.
- Vockeroth, J. R. 1973. Some new or uncommon Syrphini (Diptera: Syrphidae) from Southern Africa. Ann. Natal. Mus. 21:595-608.
- Vockeroth, J. R. 1973. The identity of some genera of Syrphini (Diptera: Syrphidae) described by Matsumura. Can. Entomol. 105:1075-1079.
- Vockeroth, J. R. 1973. Three additional synonyms of *Allograpta* (Diptera: Syrphidae). Can. Entomol. 105:1101-1104.
- Weresub, L. K. 1973. *Oidium* (Fungi) nom. cons. prop. Taxon 22:696-701.
- Wilkinson, C. 1973. Computers in biology. Can. Entomol. 105:1193-1197.
- Wu, L.-Y., and Townshend, J. L. 1973. *Paratylenchus tateae* n. sp. (Paratylenchinae, Nematoda). Can. J. Zool. 51:109-111.
- Yoshimoto, C. M. 1973. Review of North American Chrysocharis (Kratochviliana) (Eulophidae: Chalcidoidea) north of Mexico, especially species attacking birch casebearer (Lepidoptera: Coleophoridae) and birch leafminer (Hymenoptera: Tenthredinidae). Can. Entomol. 105:1309-1349.

Miscellaneous

- Arnold, J. W. 1973. Blood or hemolymph cells: Insects: respiration and circulation. Fed. Am. Soc. Exp. Biol.
- Barr, D. J. S. 1973. The use and misuse of pine pollen in chytrid research. No. 532, p. 65. 24th Annu. A.I.B.S. meeting of Biological Societies.
- Biosystematics Research Institute. 1973. Fungi Canadenses. Elliott, M. E. *Ciboria betulicola*, No. 1. Hughes, S. J. *Spadicoides bina*, No. 4; *S. atra*, No. 5; *S. obovata*, No. 6; *S. grovei*, No. 7; *S. klotzchii*, No. 8; *S. canadensis*, No. 9. Malloch, D. *Agaricus semotus*, No. 2; *Inocybe dulcamara*, No. 3. Pirozynski, K. A. *Microthynum macrosporium*, No. 10.
- Boivin, B. 1973. Marcel Raymond, 1915-1972. Taxon 22:275-278.
- Boivin, B. 1973. Lionel Cinq-Mars, 1919-1973. Can. Bot. Assoc. Bull. 6(4):3-4.
- Cody, W. J. 1973. Ram's-head lady's-slipper. Blue Jay 31:180-181.
- Cody, W. J. 1973. Index Seminum 1973. Plant Research Institute, Can. Dep. Agric. Publ. 37 pp.
- Cody, W. J., and Spicer, K. W. 1973. Report on the Vascular Plant Herbarium-1972. Greenhouse-Garden-Grass 12:27-32.
- Cody, W. J., and Talbot, S. S. 1973. The pitcher plant, *Sarracenia purpurea* L. in the north-western part of its range. Can. Field Natur. 87:318-320.
- Downes, J. A. 1973. Biting flies: the necessity for a new systematics. Pages 115-123 in A. Hudson, ed. Symposium on biting fly control and environmental quality, Edmonton, Alta. DRB Publ. No. 217.
- Downes, J.A. 1973. The biting midges (Diptera: Ceratopogonidae) as predators. Proc. Entomol. Soc. Ont. 102:181.
- Ginns, J. H. 1973. An extraordinary fungus, the giant puffball. Trail & Landscape 7:104-105.

- Hudson, A., ed. 1973. Proceedings of a symposium on biting fly control and environmental quality, Edmonton, Alta. DRB Publ. No. 217.
- McNeill, J. 1973. The sixth annual conference on numerical taxonomy, Philadelphia, October 1972. *Syst. Zool.* 22:185-190.
- Moore, R. J. 1973. Index to plant chromosome numbers 1967-1971. *Regnum Veg.* 90:539.
- Peterson, B. V. 1973. Discussion—Biological control of biting flies. Pages 89-92 *in* A. Hudson, ed. Symposium on biting fly control and environmental quality, Edmonton, Alta. DRB Publ. No. 217.
- Shetler, S. G. et al. (incl. J. McNeill). 1973. A guide for contributors to Flora North America (FNA). FNA Report 65, Smithsonian Inst., Washington.
- Slykhuis, J. T., and Barr, D. J. S. 1973. Wheat spindle streak mosaic. *Can. Agric.* 18(2):18-20.
- Small, E. 1972. The hemp problem in Canada. *Greenhouse-Garden-Grass* 11:46-52.
- Yoshimoto, C. M. 1973. Biography of Dr. Herbert Milliron, "Busy as a Bumblebee". *Bull. Entomol. Soc. Can.* 5:90-91.

Chemistry and Biology Research Institute

Ottawa, Ontario

PROFESSIONAL STAFF

G. FLEISCHMANN, B.A., M.A., Ph.D.	Director
J. W. ROUATT, B.S.A., M.Sc., Ph.D.	Assistant Director
M. G. BOTTEN (Mrs.)	Administrative Officer

Agricultural Microbiology

L. R. BARRAN, B.Sc., M.Sc., Ph.D.	Cell membrane biochemistry
C. MADHOSINGH, B.S.A., M.S., Ph.D.	Enzymology of pathogenic fungi
R. W. MILLER, B.S., Ph.D.	Fungal metabolism and enzymology
E. A. PETERSON, B.Sc., M.S., Ph.D.	Rhizosphere fungi
R. B. PRINGLE, B.Sc., M.Sc., Ph.D., F.A.A.A.S.	Host-specific toxins
J. W. ROUATT, B.S.A., M.Sc., Ph.D.	Rhizosphere bacteria and culture collection
E. F. SCHNEIDER, B.Sc., M.Sc., Ph.D.	Rest period and dormancy

Cell Bioengineering

R. M. BEHKI, B.Sc., M.Sc., Ph.D.	Plant cell transformation
S. M. LESLEY, B.Sc., M.A., Ph.D.	Plant cell hybridization; anther culture

Environmental Chemistry

R. GREENHALGH, B.Sc., Ph.D.	Organophosphorus insecticides
M. IHNAT, B.Sc., Ph.D.	Inorganic chemistry
S. U. KHAN, B.Sc., M.Sc., Ph.D.	Herbicides
W. D. MARSHALL, B.Sc., Ph.D.	Fungicides; analytical methods
J. G. SAHA, B.Sc., M.Sc. (Tech.), Ph.D.	Organochlorine and carbamate insecticides
J. C. YOUNG, B.Sc., M.Sc., Ph.D.	Analytical organic chemistry

Winterhardiness

C. J. ANDREWS, B.Sc., Ph.D.	Winter survival of seed
F. D. H. MACDOWALL, B.Sc., M.Sc., Ph.D.	Frost damage; chloroplast membrane
M. K. POMEROY, B.Sc., M.Sc., Ph.D.	Frost resistance; biochemistry and cytology
D. SIMINOVITCH, B.Sc., M.Sc., Ph.D., Ph.D., F.R.S.C.	Frost hardiness; lipids and membrane
J. C. SIROIS, B.A., B.Sc., M.Sc., Ph.D.	Growth regulators

Host-Parasite Relationships

L. N. CHYKOWSKI, B.S.A., M.Sc., Ph.D.	Leafhopper-transmitted viruses
Y. C. PALIWAL, B.S.A., M.Sc., Ph.D.	Transmission by aphids and microscopic vectors
R. C. SINHA, B.Sc., M.S., Ph.D.	Virus and mycoplasma vector relationships

Agrometeorology Research and Service

W. BAIER, Diplomlandwirt, Dr. agr., M.Sc.	Head; Agrometeorology
R. L. DESJARDINS, B.Sc., M.A., Ph.D.	Micrometeorology
S. N. EDEY, B.Sc.	Climatology
H. N. HAYHOE, B.Sc., M.S., Ph.D.	Biomathematics
C. E. OUELLET, B.A., B.Sc.A., M.Sc.	Ecoclimatology and plant survival
W. K. SLY, B.A.	Applications
G. D. V. WILLIAMS, B.S.A., M.A.	Agroclimatology

Analytical Chemistry Services

D. A. SHEARER, B.A., M.A., Ph.D., F.C.I.C.	Head
R. GREENHALGH, B.Sc., Ph.D.	Advisor; Instrumentation Centre

Electron Microscope Centre

G. H. HAGGIS, B.Sc., Ph.D.	Head
J. BRONSKILL (Miss), B.A., Ph.D.	Postal service
Y. C. PALIWAL, B.S.A., M.Sc., Ph.D.	Advisor

VISITING SCIENTISTS

J. KOVACICOVA, B.Sc., Ph.D.

Research Institute of Agrochemical Technology,
Bratislava, Czechoslovakia

Organophosphorus insecticides

National Research Council postdoctorate fellows, 1973-74

H. R. DAVIDSON, B.Sc., Ph.D.

J. SINGH, B.Sc., Ph.D.

Agrometeorology

Winterhardiness; biochemistry

INTRODUCTION

The Chemistry and Biology Research Institute was enlarged in 1973 by the addition of the Agrometeorology Research and Service, formerly part of the Plant Research Institute.

An Environmental Chemistry section, consisting of the former Pesticide Residue and Chemical Methodology sections, was also established this year to provide the Research Branch with the capacity to react to environmental problems in the field of agriculture.

The chemical services provided by the Institute to Branch establishments were combined under the Analytical Chemistry Services. These include: the Technological Services Unit, the Instrumentation Centre, Amino Acid Analysis Laboratory, Microchemical Laboratory, and Pesticide Residue Laboratory.

This report records the highlights of our progress in research and analytical services provided during 1973. Detailed information is available in the published papers listed at the end of the report. Reprints are available on request from the Chemistry and Biology Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

G. Fleischmann
Director

AGRICULTURAL MICROBIOLOGY

Alfalfa Inhibitor of *Fusarium* Growth

A relatively rapid (4-h) bioassay technique has been developed for determining the concentration and purity of a growth inhibitor of *Fusarium oxysporum* Schlecht. extracted from alfalfa roots. It is applicable also to studies on the effect of such things as toxins and pesticides on the growth of *Fusarium* spp. The assay is based on the unique sensitivity of the germ-tube initials to adverse conditions, subsequent to preserving a uniformly germinating batch of homogeneous microconidia.

Light Effects on Sterols and *Fusarium* Survival

Qualitative and quantitative gas-liquid chromatograph assays were made of the free sterols in the mycelia. Eleven different sterols were separated; the major one was ergosterol.

Studies have not yet established definite correlations between sterol content, age of mycelia, and temperature tolerance.

In vitro studies have demonstrated the photooxidation of cholesterol and ergosterol to their respective peroxides under the effect of light (380-nm light emitted from a 150-W medium pressure mercury lamp) with porphyrin mediating the peroxidation. Sterol peroxides have been shown to be destructive to certain cells.

Metabolic Control of Sterol Synthesis

An inhibitor of sterol biosynthesis obtained from mitochondria of starved rats' liver inhibited sterol synthesis in *Fusarium*. It was purified 20-fold by acid precipitation at pH 3 of the tryptic digest on the nondialyzable part of the mitochondrial extract. This precipitate has the characteristics of a low-molecular-weight conjugated peptide and also inhibited hydroxymethylglutaryl CoA reductase in preparations from rat livers, yeasts, and *F. oxysporum*.

Formation of Chlamydospores in *Fusarium*

During differentiation of *Fusarium* conidial cells to chlamydospores, a previously undescribed functional organelle is formed in the endoplasmic reticulum. The organelle, which has a unit limiting membrane, begins development before there are other recognizable changes in the cells. It attains a complete stage of development and contains vesicles and other microbodies before the chlamydospores are fully formed.

As the thick-walled chlamydospores mature, the contents of the organelles become granular and closely resemble a vacuole. The granular substance is thought to be derived from the vesicles and microbodies that formed within the organelle. The formation of the organelle and its breakdown parallel chlamydospore development.

Cell Wall Studies of *Fusarium sulphureum*

Pure cell walls of *F. sulphureum* Schlecht. were isolated and the chemical composition was studied. The cell-wall lipid, fatty acid, amino acid, amino sugars, and neutral sugar contents were determined. The inner part of the cell wall was found to be composed mainly of chitin.

Cell Transport Studies of *Fusarium sulphureum*

The transport systems for phenylalanine and lysine uptake in conidia were characterized with respect to kinetics of uptake, specificity, and the effect of respiratory inhibitors. The respective permeases were found to be relatively nonspecific for amino acid uptake.

Membrane Studies

Electron spin labeling studies of membranes of conidia and mycelia of *Fusarium* spp. are in progress. Information has been obtained on the identity of key membrane components and on alterations in membrane structure that are necessary for survival of the pathogen in the dormant state. Considerable experience in the field of electron spin labeling has been developed through attendance at workshops and scientific meetings.

Biological Oxidation

A special reagent was developed for identification of the sites of formation of activated forms of oxygen in aerobic metabolism. The reagent specifically reacts with free-radical forms of oxygen and provides a method for the quantitative determination of the concentration of such unstable radicals. The enzyme (superoxide dismutase) responsible for the removal of such radicals has been characterized in *Fusarium*. This enzyme plays an important role in protection against toxic products of endogenous metabolism of the dormant spore and is a site of possible attack by agents that might lead to control of the fungus.

Host-specific Toxins

Seventy isolates of *Helminthosporium sativum* Pamm., King & Bakke were tested for toxin production with the seedling assay method developed by Pringle and Braun. The metabolites produced by these 70 isolates in culture were compared with those of other species of host-specific toxin-producing

Helminthosporium. A number of new toxic metabolites were isolated; the most interesting one is victoxinine, a nitrogen-containing sesquiterpenoid base, which had been identified some years before as a component of the host-specific toxin of *H. victoriae* Mehan & Murphy. This compound will kill wheat plants at a concentration as low as 200 μ g/ml. In addition, several peptide conjugates of victoxinine were identified among the various strains that were tested. These compounds are analogues, in a chemical sense, of the *H. victoriae* toxin. Several compounds with ionophore properties were also found in the metabolism solutions and mycelial mats of *H. sativum*. They are able to transport a highly polar ion, such as K^+ , from an aqueous environment into a nonaqueous phase such as lipid and are able to kill plants by causing the leakage of essential ions from their cells.

Root Rot of Cereal Crops

A study of interactions between *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur and microorganisms from the root zone of two varieties of wheat that differ in common root-rot reaction showed that actinomycetes from both varieties have the capacity to stimulate growth of the root-rot pathogen by production of volatile metabolites. Some species of root-zone fungi common to both varieties may also enhance growth of *C. sativus* in a similar manner, but other species tend to restrict its growth.

CELL BIOENGINEERING

Cell Transformation

A requirement exists for plant cell DNA containing a ^{14}C or 3H label of high specific activity to be used in experiments on genetic transformation of other plant cells. The limited incorporation of the commonly used DNA precursor 2- ^{14}C thymidine into plant cells growing in liquid suspension cultures was shown to be caused by a very active pyrimidine phosphorylase found to be localized in the cell wall. The first degradation product, thymine, is rapidly metabolized through β -ureidoisobutyrate to β -aminoisobutyrate (BAIB) with the loss of the label in carbon 2 as $^{14}CO_2$. With a tritium label in the C_5 methyl position of thymidine the 3H is not lost but remains, as BAIB, in the cell where it can be mistaken for labeled DNA. Many

pyrimidine analogues and other possible inhibitors of this phosphorylase were tested and two of these will be examined further because they inhibit this enzyme without interfering with incorporation of ^{14}C -labeled thymidine into the nucleic acid of cultured cells.

Haploid Plants from Anther Cultures

The anthers of most cultivars of tobacco routinely yield some haploid plantlets, but several modifications to the media and technique have not been effective in augmenting the success ratio. About 25 cultivars of potato, including virus-free stock, have now been tested, but none have produced haploid plantlets.

ENVIRONMENTAL CHEMISTRY

Inorganic

Maleic hydrazide on tobacco and vegetables. A spectrophotometric method for measuring maleic hydrazide has been developed, which includes a preliminary distillation step to reduce levels of interfering compounds. The recoveries of microgram amounts added to 0.5 g pipe, cigar, or flue-cured tobacco, or dry or commercial dehydrated potatoes and carrots, ranged from 71% to 81%. The mean relative standard deviation of the analyses for both field-treated and fortified tobacco samples containing 1–28 $\mu\text{g/g}$ was 3%. The procedure has been submitted for interlaboratory study in conjunction with the Association of Official Analytical Chemists.

Analysis of selenium in foods. The fluorimetric procedure previously developed for determining total selenium in foods provided excellent precision and sensitivity for the analysis of samples containing 5–750 μg native or added selenium. The minimal detectable amount was 10 ng.

A collaborative study of the method was carried out. The study involved 19 laboratories and 10 samples of vegetables, cereals, dairy products, meat, and fish containing naturally occurring selenium. The coefficient of variation ranged from 65% at the 16-ng level to 5.6% at the 427-ng level. The precision and accuracy of the procedure were deemed acceptable, and the method was adopted for official first action by the Association of Official Analytical Chemists.

Organic

Honey bee pheromones. Volatile constituents of pollen that are attractive to worker bees have been investigated. A number of attractants have been isolated and partially characterized. Problems arising from the bioassay of extremely volatile compounds have been overcome.

Field tests with natural and synthetic attractants. Synthetic 9-oxo-*trans*-2-decenoic acid and ether extracts of queen heads proved to be equally attractive to drones at a distance from a lure. Other substances in the heads of both virgin and mated queens caused drones to examine a lure. However, 9-hydroxy-*trans*-2-decenoic acid failed to attract drones from a distance or to affect their behavior in the presence of the oxo compound.

The response of worker bees differed from that of the drones, in that the synthetic oxo compound was only slightly attractive and the synthetic hydroxy compound was inactive. On the other hand, ether extracts of whole queens or queen heads were highly attractive. These substances were more abundantly produced by mated, laying queens than by virgin queens.

Pesticides

Methods were developed and evaluated for determining toxaphene and diazinon in animal tissues and wool; dimethoate in wheat grain, straw, and rapeseed oil; Ethrel (Amchem Products Inc.) in apples; malathion in lettuce; and atrazine in chicken tissues, feces, and eggs. The methods were subsequently used at the Institute and at research stations to study the persistence of these pesticides in agricultural produce.

Organophosphorus insecticides. Diazinon was used on sheep in blow fly control experiments. After treatment with 0.2% and 0.4% diazinon, decay curves were established over a 2-wk period. Pesticide levels in blood, kidney, and liver fat were less than 0.02 ppm after 3 days. Wool showed levels in the order of 1,000 ppm. It was impossible to correlate the differences between the amount of pesticide found on top, side, and bottom samples of wool.

Levels of dimethoate and its oxon in wheat and soil were examined in connection with a grasshopper control program. After 7 days, wheat plants contained less than 0.01 ppm of

dimethoate, which had been applied at 140 g/ha (2 oz/ac).

A method for determining Ethrel in apples involved cleanup by ion exchange chromatography followed by derivatizations as the methyl ester. Levels of the growth regulant present in Delicious apples treated with 300 ppm before being stored at 10°C for 3 mo were in the range 1.3 to 0.4 ppm.

The uptake of fenitrothion by pine seeds was studied, and transportation through the seed coat and endosperm was established. After 10–12 days germination, two possible metabolites were identified and characterized by gas chromatography. These were the fenitrooxon and the *S*-methyl isomer. The oxon was the result of microsomal oxidation, whereas the *S*-methyl isomer is thought to arise from dealkylation by glutathione alkyl transferase followed by alkylation.

Chemical derivatization studies with pesticides were continued. In compounds with an aryl nitro moiety, e.g., parathion, fenitrothion, and EPN, metal–acid reduction was compared with that using chromous chloride. The latter method proved to be more suitable for residue confirmation.

Organochlorine insecticides. Work on the metabolism of the radioactive compounds in wheat plants was completed. About 39% of the radioactivity in wheat plants grown from lindane-¹⁴C treated seed was due to lindane itself and 61% due to metabolites. Several metabolites have been identified including all the isomers of trichlorobenzene, dichlorobenzene, 1,2,3,5- and 1,2,3,4-tetrachlorobenzene, γ -PCCH, pentachlorobenzene, 2,4,5-trichlorophenol, 2,3,4,6-tetrachlorophenol, and 2,4,6-trichlorophenol. Studies on the metabolism of lindane-¹⁴C by stored grain showed this compound is not appreciably degraded by stored grain.

The persistence and translocation of technical chlordane, AG-chlordane, fonofos, and lindane were not affected by irrigation. Similar amounts of residues were present in wheat, potatoes, carrots, rapeseed, alfalfa, and peas whether or not the treated plots were irrigated.

The ingestion of lindane or Vitavax (UniRoyal Chemical) or both by hen pheasants had no effect on the number of eggs laid per bird, hatchability, or survival of the young. Vitavax was rapidly eliminated from the birds' bodies and residues in eggs persisted less than a week.

Herbicides. Column chromatographic techniques were employed to study the interaction of bipyridylum herbicides with humic and fulvic acids. Paraquat appeared to be complexed more than diquat; the amount of both was higher in humic than in fulvic acid. The order for increasing absorption for the two herbicides was the same; aluminum was the strongest. Evidence was obtained for the involvement of ion exchange and charge transfer mechanism in the absorption process.

The equilibrium data resulting from studies of the adsorption of 2,4-D and picloram on humic acid followed the Freundlich type of isotherm. Kinetic data indicated a physical type of adsorption, with the rate-determining step for the initial period being the diffusion of the herbicide molecules to the humic acid surface. At longer time intervals, the rate-determining step was thought to be intraparticle diffusion of the herbicide molecules into the interior of the humic acid particles.

WINTERHARDINESS

Levels of Unsaturation of Membrane Lipids During Frost Hardening

Comprehensive seasonal studies in the current year on changes in tree cell lipids during frost hardening have failed to confirm the findings of the previous year in respect to changes in the degree of saturation of component fatty acids of these lipids. Contrary to the previous year's findings, relatively little increase has been observed this year in the degree of unsaturation of component fatty acids of the membrane lipids of these cells during the critical stages of hardening. The results of the previous year are being attributed tentatively to oxidation occurring during protracted processing and storage of extracted lipids before analysis. However, evidence of increases in total membrane lipids with hardening, which implies augmentation of membranes during hardening, continued to be found and substantiates the findings of all previous investigations.

Thus in regard to the degree of unsaturation of membrane lipids, the results from tree cells appear to stand in marked contrast to those from winter wheat and alfalfa wherein

considerable unsaturation of membrane lipids occurred during hardening at low temperatures.

It is evident that in the case of tree cells the underlying causes of their tolerance of the extreme stresses of freezing are to be sought, not in changes in fluidity of membranes as such arising from increased unsaturation of component fatty acids, but rather in changes in other properties of the membranes of which augmentation of membranes must be one.

Changes in Mitochondria and Mitochondrial Membranes During Hardening

Indications that the above considerations also apply to the problem of hardiness in winter wheat even where unsaturation of lipids is observed during hardening were found in the results of studies made on the structural and functional responses of mitochondria and mitochondrial membranes of different varieties of winter wheat grown at low temperatures. These studies have revealed a depression of respiratory control ratio and phosphorylative efficiency and an increase in unsaturation of the lipids respectively in the mitochondria and mitochondrial membranes during hardening, but both events appear to be unrelated to hardiness because they occur to the same degree in all varieties. As in the tree cells, therefore, other changes in the membranes or cells must account for the differences in the hardiness between different varieties of winter wheat. A temperature-dependent structural change occurring only in the mitochondrial membranes of the hardier wheats identified by spin labeling may provide a clue to one of these changes.

Proton Magnetic Resonance Studies on Wheat

Proton magnetic resonance spectrometry has been used to measure the changes in nonfreezable or bound water with hardening in different varieties of winter wheat. The amount of bound water increased with hardening, but the increase was found to be as great in a less hardy spring wheat as in a winter wheat. Reduction in growth was noted to be the physiological process most responsive to low temperature during hardening.

Environmental Effects and Endogenous Processes in Hardening

Endogenous rhythms have been further implicated in the physiological processes of hardening in trees by the observation that hardening to temperatures of liquid nitrogen can be achieved in completely severed trunks of trees collected in mid-September and maintained in the dark for 3 mo at a constant temperature of 10°C (50°F).

Dehardening of winter wheat in the field in the spring proceeded more rapidly under ice cover in known nonhardy cultivars than in hardy ones, which could account in part for the reduced winter survival of the former. Tolerance of winter wheats exposed to ice cover or ice encasement at intervals during hardening was minimal before hardening and increased progressively with hardening. Total encasement had a more depressing effect overall than partial ice cover on the final expression of the intrinsic hardiness potential. Exposure of winter wheats to periods of mild freezing during hardening increased the level of hardiness that was ultimately attained.

Growth Regulators

The peroxidase-catalyzed oxidation of indole-3-acetic acid (IAA) has been shown to be competitively inhibited by the coumarin scopoletin, presumably by preferential oxidation of the latter. Promotion of growth observed in oat coleoptiles in media containing scopoletin can be explained by this inhibition. Scopoletin free radicals appear to be involved and have been isolated and characterized.

HOST-PARASITE RELATIONSHIPS

Wheat Striate Mosaic Virus

Heating purified preparations of wheat striate mosaic virus (WSMV), obtained from infected wheat plants, up to 100°C for 20 min in the presence of 1 M NaCl (pH 7.0) did not release the viral ribonucleic acid (RNA). WSMV-RNA was obtained by treating the virus with phenol. The percentage composition of RNA was: guanine 26.4, adenine 21.3, cytosine 22.5, and uracil 29.8. The thermal inactivation point of WSMV was between 55° and 60°C as determined by infectivity bioassays. Serological studies showed that WSMV-related protein can be

detected in several internal organs of viruliferous leafhopper vector *Endria inimica* (Say), but complete virus particles could not be found in any of the tissues. The concentration of WSMV antigens was about the same in infected plants and leafhoppers, but that of infectious entity of the virus was higher in the latter per unit weight of tissues.

Southern Bean Mosaic Virus

Southern bean mosaic virus (SBMV) was degraded chemically to a subviral entity (SVE) comprising the full complement of viral RNA and about one-third of the total virus protein. Unlike SBMV, SVE was unstable in vitro and sensitive to ribonuclease, and the particles lacked discrete morphology. It appears that in SBMV particles, about two-thirds of the total protein subunits are arranged to constitute an outer rigid capsid, which surrounds an internal "loose" complex of RNA and the remainder of the viral protein.

Barley Yellow Dwarf Virus

Using globulins isolated from a barley yellow dwarf virus (BYDV) antiserum having a titer of 1/512 (ring interface test), a bentonite flocculation test for detecting small amounts of antigens was standardized for BYDV. Of the several concentrations of globulins tested, the most sensitive bentonite-antibody conjugates were obtained at a globulin concentration corresponding to about one-half the antiserum titer. Sensitized bentonite detected as little as 0.9 μ g of purified virus in 0.1-ml samples.

Strawberry Green Petal Survey

A coordinated survey was made in the first production year of commercial fields of the cultivars Redcoat, Sparkle, and Cavalier in Quebec and the Maritime Provinces in 1971 and 1972. The low level of infection (less than 3%) and low calculated losses indicated that the disease was not of economic importance for strawberries. The occurrence of the disease in the Terrebonne - Deux Montagnes area of Quebec suggested a westward spread of the disease.

Clover Phyllody Host Range

Additional plant species were found susceptible to clover phyllody, bringing the total known host range to 79 species in 22 families. The wide host range of both the causal

agent and the aster leafhopper vector, *Macrosteles fascifrons* (Stål), includes weeds and cultivated crop plants and emphasizes the potential importance of the disease.

Newly Discovered Vectors

Athysanus argentarius Metc., a grass-feeding leafhopper, transmitted a celery-infecting strain of aster yellows from barley to barley. Transmission was less efficient by *A. argentarius* than by *M. fascifrons*.

Aphrodes bicincta (von Schrank), a polyphagous feeder, transmitted the same aster yellows strain from celery and aster to Ladino clover and appeared to be a relatively efficient vector.

AGROMETEOROLOGY RESEARCH AND SERVICE

Agroclimatic Data

The first year of cooperation in data acquisition through worldwide experiments organized by the Commission for Agricultural Meteorology of the World Meteorological Organization was successfully completed. Meteorological and biological data relative to eight varieties of wheat were collected in eight major wheat-producing countries according to standardized experimental conditions. The participants will obtain computer listings of these crop-weather data to be used in the development and testing of crop simulation models and their application to agroclimatic surveys. Scientists also participated, for the first year, in a second global experiment concerned with physical measurements relative to the minimum temperature near the ground. These data will also become available for research.

Model Development

Ecosystem assessment. A statistical description of the radiation, temperature, wind, and CO₂ fluctuations above and within a corn crop showed that CO₂ enrichment under field conditions would be inefficient under most meteorological conditions because turbulent diffusion would be too active to maintain high CO₂ concentration in plant canopies.

A system that measures the atmospheric CO₂ flux for any crop was used to measure the CO₂ evolution from bare soil and the atmospheric CO₂ flux above a legume hay

crop. The results indicated that at times the contribution of CO₂ from the soil can be 30% of the total CO₂ contribution.

Management operations. A Markov chain probability model has been developed and applied to the analysis of the probability of sequences of field workdays occurring at selected locations across Canada. In cooperation with the Experimental Farm at Nappan, data on the field drying of forages were analyzed to determine the suitability of selected meteorological parameters for measuring the weather effects on drying rates. Using results from this study, the probability of suitable forage-drying weather occurring at various locations in Quebec and Nova Scotia was estimated.

Soil temperatures. A climatological soil temperature model was completed, and the monthly soil temperature normals down to 150 cm were estimated for 623 stations across Canada. These estimates were compared with soil temperatures averaged over 5 to 9 yr from 18 stations across Canada for the 20- and 100-cm depths. The differences did not exceed 1.0°C in 77% of 208 cases considered and were less than 2.0°C in 95% of the cases.

Agroclimatic analysis. Research into the relationships between crop-district-cereal yields and weather and soils continued. Estimates based on weather data to the end of May were of little value and generally differed from actual yields by as much as 2.7–3.6 hl/ha (3–4 bu/ac). When data to the end of July were included, the estimates were generally within about 1.8 hl/ha (2 bu/ac) of actual yields. Investigation also continued into the losses of climatically favored farmland that are occurring because of urban expansion. There was an encouraging increase in the amount of consultation and cooperation with soil scientists.

Soil moisture. Research continued into the verification of soil moisture estimates from the Versatile Budget against actual soil moisture measurements for the 1968–72 period at eight selected stations participating in the National Soil Moisture Program. Feedback from users of the Versatile Soil Moisture Budget resulted in further improvements of the model.

Applications and Services

The feasibility of periodically assessing, prior to harvest, prairie cereal production prospects as influenced by weather was demonstrated in a pilot project during the summer of 1973. Weather-based estimates of wheat, barley, and oat yields were provided weekly to senior officials of the Department, the Canadian Wheat Board, and other grain groups on a restricted basis.

Objective methods of simulating irrigation scheduling for different crops and soils, based on daily weather conditions, have been perfected and are ready for use with current or historical climatic data. The technique has also been adapted to simulate the effects on the total supplemental water required with different application equipment. Techniques developed for deriving data for showing Canadian regimes of moisture and temperature conditions important to agriculture have been described.

Extensive services, particularly in the field of soil moisture and crop production, were provided to agricultural researchers in the Department and to other agencies and organizations. Assistance in using the Versatile Budget for computing soil water content from climatic data was given to a number of national and international agricultural research institutes. Other applications of the model were concerned with determining climatological field workdays for selected locations in Canada.

A comparative analysis of annual, monthly, and daily soil and air temperatures at Ottawa with implications for various agricultural practices has been completed.

Agrometeorological Computer Services

The data processing support and services provided to researchers and user agencies have continued to become more diversified. In support of expanding services and research applications, development of the data archive continued. Considerable progress was made in applications of the SYMAP program in connection with yield estimation studies, farmland losses, and contouring building sites.

ANALYTICAL CHEMISTRY SERVICES

The Analytical Chemistry Services section comprises five analytical units, which carry

out service analyses for research scientists throughout the Branch.

Technological Services Unit and Micro Analytical Laboratory

During the fiscal year 1972-73 the Technological Services Unit and Micro Analytical Laboratory analyzed 31,342 samples from research institutes (49%), eastern research stations (28%), and western research stations (22%), an increase of 31% over the previous year. The backlog of samples was reduced substantially.

Instrumentation Centre

In the Instrumentation Centre, 1,319 spectra consisting of 94 IR, 89 NMR, 610 electron paramagnetic resonance (EPR), and 526 mass (including GC-MS) spectra were prepared mainly for research institutes in Ottawa.

Amino Acid Analysis Laboratory

The capacity for analysis in this laboratory has this year been increased 10-fold with the acquisition of two new amino acid analyzers together with a data reduction system. Thus, amino acid analyses on protein hydrolyzates and physiological fluids can now be carried out in greatly increased numbers. In the last 9 mo of 1973, 485 samples were analyzed.

Pesticide Residue Service

This service was begun in May to meet demands for residue analyses by research scientists at Branch establishments that lack facilities for this work. With only one technician in the laboratory 197 samples, including 126 for DDT and 63 for diazinon, were analyzed.

ELECTRON MICROSCOPE CENTRE

The installation of an additional scanning electron microscope in 1973 enables the Electron Microscope Centre to handle the very great and still increasing demand for research time on these instruments. The cold stage developed for use with the Stereoscan for the examination of frozen samples has proved very successful and is now in routine use.

The service whereby samples can be sent by post to Ottawa for electron microscope examination from Branch establishments across the country is now in full operation. The requests received from research stations for examination of biological materials were successfully processed. Two of these were for the identification of plant diseases by transmission electron microscopy and two were for scanning electron microscopy studies on plant surface samples.

PUBLICATIONS

Research

Baier, W. 1973. Crop-weather analysis model: 1. Summary. *Int. J. Biometeorol.* 17:313-320.

Baier, W. 1973. Crop-weather analysis model: 2. Review and model development. *J. Appl. Meteorol.* 12:937-947.

Baier, W. 1973. Introductory remarks—Part I: Computer simulation (Symposium on effects of weather and climate on plants and trees.) *Int. J. Biometeorol.* 17:311-312.

Baier, W., and Mack, A. R. 1973. Development of soil temperature and soil water criteria for characterizing soil climates in Canada. *Soil Sci. Soc. Am. Proc.* 37:195-212.

Baier, W., Sharp, W. R., and Roberts, J. G. 1973. Recent developments in preparing colored agroclimatic maps by computer. *Can. J. Soil Sci.* 53:133-134.

Behki, R. M., and Lesley, S. M. 1973. Effect of uridine on the incorporation of thymine and thymidine in *Escherichia coli*. *Can. J. Microbiol.* 19:485-490.

Boch, R., Shearer, D. A., and Shimanuki, H. 1973. Effect of ethylene oxide fumigation on amino acid composition of pollen. *J. Environ. Entomol.* 2:937-938.

Capoor, S. P., Pande, P. K., and Sinha, R. C. 1973. Mycoplasma-like bodies found in cells of "small leaf" affected cotton plants. *Hind. Antibiot. Bull.* 15:40-41.

Chiolkowski, L. N. 1973. Effectiveness of antibiotics applied as postinoculation sprays against clover phyllody and aster yellows. *Can. J. Plant Sci.* 53:87-91.

- Chiolkowski, L. N. 1973. Factors affecting the infection of plants with clover phyllody agent transmitted by *Macrosteles fascifrons*. Ann. Entomol. Soc. Am. 66:987-990.
- Chiolkowski, L. N., Colpitts, S. R., Coulombe, L. J., Delbridge, R. W., Gourley, C. O., Lawrence, C. R., Murray, R. A., Santerre, J., and Thompson, L. S. 1973. Strawberry green petal disease in Quebec and the Maritime Provinces in 1971 and 1972. Can. Plant Dis. Surv. 53:63-66.
- Cochrane, W. P., Wilson, B. P., and Greenhalgh, R. 1973. Determination of sulphur and chlorine containing pesticides and electrolytic conductivity detectors. J. Chromatogr. 75:207-218.
- de la Roche, I. A., Andrews, C. J., and Kates, M. 1973. Changes in phospholipid composition of a winter wheat during germination at 2°C and 24°C. Plant Physiol. 51:468-473.
- Desjardins, R. L., Sinclair, T., and Lemon, E. 1973. Light fluctuations in corn. Agron. J. 65:904-908.
- Fowler, D. B., Siminovitch, D., and Pomeroy, M. K. 1973. Evaluation of an artificial test for frost hardiness. Can. J. Plant Sci. 53:53-59.
- Greenhalgh, R., and Wood, P. J. 1973. The detection of boron and the response of some boronate derivatives of carbohydrates with an alkali flame ionization detector. J. Chromatogr. 82:410.
- Haggis, G. H., and Brooks, S. 1973. Scanning electron microscopy of rat liver. Lab. Invest. 29:60.
- Hayhoe, H. N. 1973. Weather effects on field drying of forages—A review. Nat. Can. (Que.) 100:393-405.
- Ihnat, M., Westerby, R. J., and Hoffman, I. 1973. Determination of maleic hydrazide residues in tobacco and vegetables. J. Assoc. Off. Anal. Chem. 56:1164-1172.
- Karapally, J. C., Saha, J. G., and Lee, Y. W. 1973. Metabolism of lindane-¹⁴C in the rabbit; ether-soluble urinary metabolites. J. Agric. Food Chem. 21:811-818.
- Lesley, S. M., and Behki, R. M. 1973. Sensitivity of Myxin of *Escherichia coli* treated with ethylenediaminetetraacetic acid. Can. J. Microbiol. 19:531-533.
- Macdowall, F. D. H. 1973. Growth kinetics of Marquis wheat. IV. Temperature dependence. Can. J. Bot. 51:729-736.
- Macdowall, F. D. H. 1973. Growth dependence of Marquis wheat. V. Morphogenic dependence. Can. J. Bot. 51:1259-1265.
- Miller, R. W. 1973. Allosteric inhibitors. Pages 1-44 in Hochster, Kates, and Quastel, eds. Metabolic inhibitors. Vol IV. Academic Press, New York.
- Miller, R. W., and Rapp, U. 1973. The oxidation of catechols by reduced flavins and dehydrogenases. An electron spin resonance study of the kinetics and initial products of oxidation. J. Biol. Chem. 248:6084-6090.
- Ouellet, C. E. 1973. Macroclimatic model for estimating monthly soil temperatures under short-grass cover in Canada. Can. J. Soil Sci. 53:263-274.
- Parups, E. V., and Peterson, E. A. 1973. Inhibition of ethylene production in plant tissues by 8-hydroxyquinoline. Can. J. Plant Sci. 53:351-353.
- Pomeroy, M. K., and Fowler, D. B. 1973. Use of lethal dose temperature estimates as indices of frost tolerance for wheat cold acclimated under natural and controlled environments. Can. J. Plant Sci. 53:489-494.
- Pomeroy, M. K., de la Roche, I., and Miller, R. W. 1973. Structural and functional responses of wheat mitochondria to growth at low temperature. Plant Physiol. 51, Suppl. 26.
- Pringle, R. B. 1973. Abolishment of specific toxicity of host-specific toxin of *Helminthosporium carbonum* by electrolytic reduction. Plant Physiol. 51:403-404.
- Rapp, U., Adams, W. C., and Miller, R. W. 1973. Purification of superoxide dismutase from fungi and characterization of the reaction of the enzyme with catechols by electron spin resonance spectroscopy. Can. J. Biochem. 51:158-171.
- Rorke, M. A., Gardner, D. R., and Greenhalgh, R. 1973. Lethality and behavioural symptoms produced by some organophosphorus compounds in snails. Bull. Environ. Contam. & Toxicol. 9:1210.
- Saha, J., Burrage, G. H., Neilson, M. A., and Sumner, A. K. 1973. Chlordane residues in potatoes grown in treated soil and their reduction by home processing. J. Econ. Entomol. 66:1125-1127.
- Saha, M., Sumner, A. K., and Saha, J. G. 1973. Comparison of three extraction and cleanup methods for determining carbon-14-labeled residues from wheat plants grown in soil treated with Dyfonate-ring-¹⁴C. J. Assoc. Off. Anal. Chem. 56:45-48.
- Schneider, E. F., and Seaman, W. L. 1973. Changes in fine structure during the conversion of conidia cells into chlamydospores in *Fusarium*. Plant Physiol. 51:61.

- Sinha, R. C. 1973. Viruses and leafhoppers. Pages 493-511 in A. J. Gibbs, ed. Viruses and invertebrates. North Holland Publishing Company, Amsterdam.
- Sinha, R. C. 1973. Virus-like particles in salivary glands of leafhoppers *Endria inimica*. Virology 51:244-246.
- Thottappilly, G., and Sinha, R. C. 1973. Serological analysis of wheat striate mosaic virus and its soluble antigen. Virology 53:312-318.
- Williams, G. D. V. 1973. Estimates of prairie provincial wheat yields based on precipitation and potential evapotranspiration. Can. J. Plant Sci. 53:17-30.
- Young, J. C., Brownlee, R. G., Rodin, J. O., Hildebrand, D. N., Silverstein, R. M., Wood, D. L., Birch, M. C., and Browne, L. E. 1973. Identification of linalool produced by two species of bark beetles of the genus *Ips*. J. Insect Physiol. 19:1615-1622.
- Young, J. C., Silverstein, R. M., and Birch, M. C. 1973. Aggregation pheromone of the beetle *Ips confusus*: Isolation and identification. J. Insect Physiol. 19:2273-2277.
- Miscellaneous**
- Andrews, C. J., Pomeroy, M. K., and de la Roche, I. A. 1973. Cold acclimation of winter wheat during early seedling growth. Plant Physiol. Abstr. 51:26.
- Desjardins, R. L. 1973. Plant growth—the response to an everchanging environment. Can. Agric. 18(3):7-9.
- Desjardins, R. L., and Baier, W. 1973. The use of micrometeorological techniques to evaluate field management practices. Greenhouse-Garden-Grass 13(1):1-5.
- Edey, S. N. 1973. Climatic conditions in tobacco growing areas. The Lighter 43(1):44-45; (2):36-37; (3):40-41; (4):44-45.
- Haggis, G. H. 1973. Curso de microscopia eletronica. CENA publication, Piracicaba, Brazil. 57 pp.
- Macdowall, F. D. H. 1973. Tobacco and photochemical air pollution. The Lighter 43(3):5-7.
- Macdowall, F. D. H. 1973. Protection from ozone by nitric oxide. The Lighter 43(3):14-17.
- Ouellet, C. E. 1973. Plant growth—two temperature regimes. Can. Agric. 18(2):24-25.
- Ouellet, C. E. 1973. Freezing temperatures in the top soil layer. Soil Horiz. 14(1):1-2.
- Saha, J. G. 1973. Biting fly control and environmental quality. Proc. Symp. Univ. Alta. Edmonton, May 16-18, 1972. pp. 19-34.
- Siminovitch, D., de la Roche, I., and Rheaume, B. 1973. New net synthesis of membrane phospholipids of increased unsaturation correlated with development of extreme frost resistance in black locust tree bark. Abstracts. Proc. Annu. Meet. Am. & Can. Soc. Plant Physiol. 51:25.
- Sly, W. K. 1973. Maps of derived climatic data for agriculture. Can. Agric. 18(3):36-39.
- Williams, G. D. V. 1973. Urban expansion and the Canadian agroclimatic resource problem. Greenhouse-Garden-Grass 12(1):15-26.
- Williams, G. D. V. 1973. The loss of good agricultural land due to urban expansion in Canada. In Abstracts: Canadian Association of Geographers 1973 Conference, Lakehead University, Thunder Bay, Ont.

Food Research Institute

Ottawa, Ontario

PROFESSIONAL STAFF

M. R. SAHASRABUDHE, B.Sc., M.Sc., Ph.D.
J. JOANISSE

Acting Director
Administrative Officer

Food Research Liaison

M. R. SAHASRABUDHE, B.Sc., M.Sc., Ph.D.

Liaison Officer

Food Processing

D. B. EMMONS, B.S.A., M.S., Ph.D.
H. W. MODLER, B.S.A., M.S., Ph.D.
A. C. NUNES, B.Sc.
D. PATON, B.Sc., Ph.D.
C. J. RANDALL, B.Sc., M.Sc., Ph.D.
R. J. WASIK, B.Sc., M.Sc., Ph.D.

Dairy technology
Dairy technology
Dairy technology
Cereal technology
Meat technology
Cereal technology

Food Microbiology

J. A. ELLIOTT,¹ B.S.A., M.Sc., Ph.D.
R. P. SINHA, B.Sc., M.S., Ph.D.
A. R. YATES,² B.S.A., Ph.D.

Section Head; Bacteriophage
Microbial genetics
Milk quality

Food Chemistry

W. A. MCGUGAN, B.S.A., Ph.D.
A. B. DURKEE, B.Sc., M.Sc.
M. E. MCKILLICAN (Miss), B.Sc., M.S., Ph.D.

Section Head; Cheddar cheese
aroma
Chemistry of phenolics
Lipids

Carbohydrates

I. R. SIDDIQUI, B.Sc., M.Sc., Ph.D., D.Sc., F.R.I.C.

Section Head; Rapeseed
carbohydrates

P. J. WOOD, B.Sc., Ph.D.

Rapeseed carbohydrates

Protein

M. KALAB, M.Sc., Ph.D.

Section Head; Milk protein
gelation

V. R. HARWALKAR,³ B.Sc., M.Sc., Ph.D.

Milk protein gelation

J. D. JONES, B.Sc., M.Sc., Ph.D., F.R.I.C.

Rapeseed protein

J. R. QUINN, B.S.A., M.S., Ph.D.

Functional properties

C. G. ZARKADAS, B.S.A., M.Sc., Ph.D.

Beef muscle

Research Services

M. R. SAHASRABUDHE, B.Sc., M.Sc., Ph.D.

Section Head

E. LARMOND (Mrs.), B.Sc.

Sensory evaluation

Departures

G. W. HOPE, B.Sc., M.A.

Rape protein technology

Resigned June 1973

R. P. A. SIMS, B.Sc., Ph.D., F.C.I.C.

Director

Appointed Research Coordinator (Field and
Oilseed Crops), April 1973

VISITING SCIENTISTS

F. BENDER, D. Ingr. Chem.

Chemistry of sulfur compounds,

Research Associate

Oilseed Program

A. HOSONO, B.A., M.A., Ph.D.

Microbial physiology,

National Research Council postdoctorate fellow,
1972-73

Dairy Program

¹Seconded to be Acting Coordinator (Food).

²On loan to FAO, Malaysia, until April 30, 1973.

³On transfer of work at The Netherlands Institute for Dairy Research, Ede, The Netherlands.

INTRODUCTION

The programs of the Food Research Institute are concerned primarily with research and development for the optimum utilization of Canadian agricultural raw materials for food. The Institute carries out extensive research in chemistry, microbiology, and processing technology of dairy products, oilseeds, meats, cereals, and field crops. The Institute also provides a research service to the food industry in product development, quality criteria development, and product evaluation. Representatives from eight food industries across Canada participated in the short course on sensory evaluation this year. This report summarizes the progress made during 1973 in research on some of the projects.

During the year, Dr. R. P. A. Sims, who has been the Director of the Food Research Institute for the past 11 yr, became Research Coordinator (Field and Oilseed Crops). Dr. John Holme was appointed as the Director effective January 2, 1974.

Reprints of the papers listed at the end of this chapter and further details about research projects are available upon request by writing to: Food Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Madhu R. Sahasrabudhe
Acting Director

DAIRY PRODUCTS

Cheddar Cheese Flavor

Fruity flavor. Commercial Cheddar cheese samples were analyzed for ethanol and ethyl esters. With one exception, six samples of fruity-flavored cheese showed a direct relationship between flavor and high ethanol and ethyl ester contents. Ethyl esters of fatty acids are the principal components responsible for the fruity flavor as confirmed by gas-liquid chromatography (GLC) of the distillates from fruity cheese.

Volatile flavor components. Attempts were renewed to simulate Cheddar flavor with mixtures of compounds known to be present in Cheddar. The incorporation of low levels of phenolic compounds had a blending effect as well as imparting characteristics that closely approach the flavor of the fat fraction of aged Cheddar.

Flavor thresholds. The lowest concentrations of β -Ionone that could be detected by odor varied among individuals by factors up to 500. If such a broad range of sensitivity is general for volatile flavor components, the number of trace components of significance in a food flavor will be greater for individuals with the high sensitivities.

Milk-coagulating Enzymes

Bovine pepsin. Extracts from adult bovine stomachs with a pepsin-to-rennin ratio of 94:6 were compared with those from calf stomachs with a pepsin-to-rennin ratio of 6:94 in two commercial cheese-making operations. Ten pairs of vats were made with the two enzymes at each factory in June 1973. Minor differences were noted in the rate of coagulation and the development of acidity. Flavors and textures were similar at 3 wk and at 3 mo of age. Fat and N (protein and nonprotein) levels in whey were higher with bovine pepsin and yields were lower by 0.74%.

Starter Cultures

Bacteriophage. Pseudoplaques were observed on lawns of several strains of starter bacteria when calcium borongluconate was used as the source of calcium ions. Material from plates showing many plaques was used to infect lawns of all the strains in our laboratory. None of the strains showed plaques. It is unlikely that all these strains would be lysogenic. Calcium chloride was found to be a satisfactory source of calcium.

Multiple antibiotic resistance in starter cultures. The presence of multiple-drug-resistant factors (R factors) is known in certain types of bacteria. The R factors are extrachromosomal, small DNA molecules, which are much smaller than the nuclear

chromosome. They are of public health concern because they can be transferred, at least among related strains of pathogenic organisms.

Several strains of *Streptococcus cremoris* showed resistance to seven antibiotics: neomycin, tetracycline, streptomycin, kanamycin, ampicillin, erythromycin, and chloramphenicol. One strain (AM₁) was selected for further testing by ultracentrifugation in a cesium chloride density gradient and was found to contain an extrachromosomal band of DNA (R factor). A substrain, isolated by curing, was sensitive to all the drugs and did not contain the R factor; it was slower growing and sensitive to ultraviolet rays. The data indicated that R factors exist in bacteria used for cheese making and that some important characteristics of the bacteria are associated with drug resistance.

Milk Protein Gels

Ultrastructure of yogurts. Yogurts were made from plain skim milk with or without thickening agents such as carrageenin, gelatin, and starch. Ultrastructure of such yogurts was studied by scanning (SEM) and transmission electron microscopy (TEM).

The globular shape of casein micelles was preserved in all yogurts, and the micelles were linked into short chains or quasispherical clusters composing the three-dimensional network.

In contrast to gelatin and starch, carrageenin changed the ultrastructure drastically. A great proportion of thin and long fibers permeating the entire yogurt ultrastructure was found in the presence of carrageenin. This typical ultrastructure was not observed with other additives. Starch-supplemented yogurts contained some fibers, but gelatin did not produce any significant changes in the ultrastructure of yogurts.

TEM showed the presence of small electron-dense particles associated with lactic bacteria in some yogurts.

Relationship between firmness and ultrastructure of heat-induced milk gels. Skim milk gels of varying firmness were made by heating suspensions of 40–60% milk solids in water or in solutions of various salts. SEM and TEM showed a close correlation between the ultrastructure and firmness of the gels under study. In gels containing 40% and 50% total solids (14% and 17% protein), casein micelles appeared as individual globules

linked by some bridging material. At 60% total solids (20% protein), the micelles were fused and offered a considerably higher resistance when examined with a penetrometer. Additives that promoted gelation and increased gel firmness (ammonium persulfate, calcium chloride) caused the micelles to fuse; chemicals that inhibited gelation and produced soft gels (sodium hexametaphosphate) caused the casein micelles to disintegrate.

Sulfur in milk gels. In addition to calcium cations, sulfhydryl groups present in milk proteins play an important role in the gelation of milk. The ultrastructure of heat-induced gels consists of casein micelles linked with each other by some bridging material. Whey proteins added to milk strengthened the ultrastructure. Because it has been found that whey proteins contain about 80% of the total sulfur content of milk, a study concerned with the distribution of sulfur (sulfhydryl and disulfide groups) in the gels was started. Sulfur in the SH form was coupled with silver and then studied by TEM. Preliminary results indicated that most of the sulfur is in casein micelles and not in the binding material in gels. This may mean that whey proteins permeate the porous casein micelles and are trapped during gelation.

New Fluid Milk Products

Based on a consumer attitude study conducted by the Ontario Milk Marketing Board, two new products were developed: a fortified low-fat (0.5%) milk, and flavored milks that appeal to adults.

Milks of varied fat content (0.0%, 0.25%, 0.5%, and 2.0%) with up to 3% added solids-not-fat (SNF) were rated by panels of 12 tasters for richness, sweetness, off-flavor, appearance, viscosity, acceptability, and preference. Concentrated skim milk as a source of SNF was preferred for flavor to low-heat skim-milk powder; optimum levels of added SNF were 1.5%, 1.5%, and 1.0% for milks containing 0.0%, 0.25%, and 0.5% fat respectively. The three levels were tested by large panels (100–120 persons) for preference over skim milk and 2% milk. Milk containing 0.5% fat and 10% SNF (1.0% added) was selected for market testing.

Flavored milks containing 0.5% fat were similarly developed with flavors of mint-chocolate, mocha, and coffee. Of these, mint-chocolate and mocha were selected for market testing.

Whey utilization. A survey on whey disposal and utilization, conducted in cooperation with the Dairy Division, showed that in 1972 cheese factories in Canada produced 1.2 billion (10⁹) kg (2.6 billion lb) of whey of which 0.1 billion kg (0.2 billion lb) (8%) were fed to animals, 0.6 billion kg (1.3 billion lb) (48%) were utilized as a concentrate or dry powder, and 0.5 billion kg (1.1 billion lb) (44%) were disposed of by municipal or plant sewage systems or by spraying on fields.

Milk Powder

Moisture in skim milk powder. A Kraft bag laminated to aluminum foil and polyethylene with a rolled-steel tie closure proved to be the most suitable container for transporting and storing samples of skim-milk powder. Over a period of 21 days at 30°C and 75% relative humidity, moisture absorption in the powder was less than 0.1%.

Problems in reproducing moisture determinations by the method of the Association of Official Analytical Chemists were traced to the differences in temperature at various points in a vacuum oven. In four out of the five ovens evaluated, the temperature varied by 13 to 21°C; in the fifth oven the range was less than 4°C. An oven enclosed in an oil bath (no longer available commercially) showed a variation of only 2°C.

OIL SEEDS

Rapeseed and Mustard Seed

Investigations on the chemical composition of rapeseed and mustard seed were continued. Quantities of meals were processed for detoxification and evaluation as sources of protein for food use.

Rapeseed carbohydrates. The characterization and fractionation of the oxalate-soluble polysaccharides of rapeseed have been continued. A purified homogeneous arabinan free of N and ash was prepared by fractionation on *O*-(diethylaminoethyl)cellulose (borate form) and Sephadex G-75. The arabinose units are exclusively in the furanoid form and occur as the L-isomer. Methylation and periodate oxidation showed

that the arabinan has a highly branched structure with an average repeating unit of 27 sugar residues comprising 11 terminal, nonreducing end groups, 9 residues involved in branching through the 3,5 and 2,3,5 positions, and 7 nonterminal residues with 1 → 5 linkages. The highly negative specific optical rotation of the unmethylated ($[\alpha]_D -181^\circ$) and methylated ($[\alpha]_D -167.5^\circ$) arabinans suggests that the majority of sugar residues are of the α -L-type.

Rapeseed and mustard seed arabinans differ in structure from those of soybean in their lack of 1,2,5-linked arabinose residues.

Hemagglutinating activity (HA). The HA factor in rapeseed has been partially fractionated by ammonium sulfate precipitation and *O*-(carboxymethyl)cellulose chromatography. Difficulties were encountered in retaining the HA during fractionation.

Phenolic and other physiologically active compounds. Significant amounts of sinapic acid and lesser amounts of *p*-coumaric, *p*-hydroxybenzoic, caffeic, and ferulic acids were identified in meals and hulls of rapeseed and yellow mustard. These occur as soluble and insoluble esters rather than glycosides. Water extraction of the oil-free meal only partially removed the phenolic compounds.

The absence of gallic, syringic, and vanillic acids and the occurrence of significant quantities of soluble sinapic acid suggested that the lignin content of rapeseed meal is low. The phenolic compounds identified to date are common to many plant species and are not considered toxic at existing levels, but they may cause problems of discoloration and off-flavor during processing.

Quantitative measurement of glucosinolates in rapeseed flours continues to be a problem because the acceptable levels are difficult to quantitate. A method based on spectrophotometric measurement of substituted thioureas formed by conversion of isothiocyanates is being investigated in collaboration with other laboratories.

Proteins. Solubility and molecular-weight profiles in sodium dodecyl sulfate (SDS) solutions were determined for rapeseed meal extracted with water, sodium chloride, and calcium chloride at pH values ranging from 2.5 to 11.0. Most of the solubilized proteins fall into three molecular-weight groups: I, 15,000–20,000; II, 25,000–30,000; and III,

about 60,000. Reduction of disulfide groups lowered the molecular weight of all groups. Calcium chloride solutions (5%) agglomerated the proteins of groups II and III to polymers of high molecular weight, which remained undissociated in 1% SDS or in dithiothreitol solution. Unlike soybean proteins, the rapeseed proteins could not be purified or concentrated by pH manipulation alone.

Lipids. Free and bound lipids were extracted from mature seeds of *Brassica campestris* L. var. Yellow Sarson and separated into polar and nonpolar fractions by chromatography. The nonpolar fractions of both free and bound lipids consisted mainly of triglycerides with small amounts of steryl esters, free sterols, monoglycerides, diglycerides, and free fatty acids. The principal components of the polar bound lipid were phosphatidyl choline, phosphatidyl ethanolamine, phosphatidyl inositol, and steryl glycoside. In the polar free lipid there was more phosphatidyl inositol and less phosphatidyl choline and phosphatidyl ethanolamine. The erucic acid content was much greater in the nonpolar fractions and in the polar free lipid than in the polar bound lipid.

Processing and evaluation. Processing comprised removal and separation of the seed coats (hulls), detoxification by hot water treatment accompanied by water leaching of the glucosinolates, and solvent extraction of the oil from the dehulled, water-extracted seed. The process yields hulls, aqueous extract, oil, and meal.

Hull fractions separated from six varieties of rapeseed, one of brown mustard, and one of yellow mustard were evaluated for toxicity. When incorporated in diets of rats all the rapeseed varieties except Bronowski, which is low in glucosinolate, produced enlarged thyroids and livers. The mustard hulls showed no toxic effect. The hulls had no detrimental effect on the test animals apart from the toxicity caused by their goitrin contamination.

Aqueous extracts contained 20–25% by weight of the dehulled seed. The chemical composition of the extracts indicated that extracts would have to be treated before disposal.

A sample of rapeseed oil with a very low content of erucic acid (0.25%) was prepared for nutritional evaluation.

Rapeseed oil was fractionated into four fractions based on unsaponifiable matter and neutral triglycerides, by molecular distillation for nutritional evaluation.

Mink are sensitive to glucosinolates. There were indications that diets containing rapeseed flour were less palatable than the control diets based on meat. However, the test diets improved the fur characteristics.

A sample of Echo (*B. campestris*) flour was evaluated for subacute toxicity with beagle dogs and rats. The dogs showed a mild hypothyroidism when the test flour comprised 40% of the dietary protein. The rats produced more discernible effects compatible with hypothyroidism. The growth rate and clinical health of both dogs and rats appeared to be unaffected, and there was no evidence of toxic effects other than those caused by isothiocyanates and goitrin (glucosinolates). Further tests with flours containing a lower level of glucosinolates are warranted.

Several rapeseed and mustard flours were subjected to protein quality assessment in rats. It has been demonstrated consistently that both rapeseed and mustard flours contain protein nutritionally equal to casein, as shown by evaluation of the Protein Efficiency Ratio (PER).

Similar tests on Span rapeseed flours prepared by various heat treatments showed no improvement over a 2-min boiling water treatment. Flours prepared without heat treatment and aqueous extraction were very toxic to rats.

Bronowski flour preparations showed no goitrogenic effects in weanling rats when fed over a 28-day period. This observation, together with calculations of the possible significance of goitrogenic intake by man, suggested that Bronowski flour preparations might be suitable for use as food.

The rapeseed harvest of 1972 contained frost-damaged green seed. Efforts to prevent the extraction of chlorophyll pigments with the oil proved unsuccessful, and the oil from green, frost-damaged seed was unsuitable for oil refining.

A commercial pulverized Bronowski meal (crude protein 43%, fiber 13.8%) was air classified into a protein-enriched fraction (protein 49%, fiber 8.6%) and a fraction high in fiber (protein 40%, fiber 18.8%).

Rapeseed and mustard seed flours were successfully incorporated into bakery products (5–10% in white bread, cakes,

doughnuts, and butter cakes; 5%, 10%, and 15% in whole-wheat bread) and meat mixtures (25% replacement of beef in meat loaf). The products compared favorably with those containing soya flours used at the same levels.

MEAT AND MEAT PRODUCTS

Proteins

Amino acid analysis. A simple chromatographic method was developed for the estimation of methylated basic amino acids in proteins.

The novel quantitative separation of methylated lysines, histidines and arginines, hydroxylysines, other basic amino acids, and related compounds is achieved with Durum-type DC-6A spherical ($11.0 \pm 1 \mu\text{m}$) resin on a single column ($58 \times 0.9 \text{ cm}$), using one buffer ($\text{pH } 5.734 \pm 0.02$), one flow rate (30.0 ml/h), and one temperature (28°C). The method is being applied to the estimation of meat proteins in foods.

Effects of rigor mortis on beef muscle. Proteins of bovine cardiac and skeletal muscles, namely, myosin, actin, actomyosin, and phosphorylase, were isolated from the muscle at death and at regular time intervals during onset and resolution of rigor mortis. They were purified and characterized with respect to their enzymic, optical, and physico-chemical properties, and their amino acid composition. Preliminary results indicated that both skeletal and cardiac myosins are highly asymmetric semirigid molecules with a molecular weight in the order of 4.7×10^5 . They display nonideality even in solvent buffers of high ionic strength at neutral pH. The two proteins are also very similar in terms of molecular size, shape, and secondary structure. Myosin solutions exhibited negative dichroic bands at 221 and $209 \mu\text{m}$ and time-dependent melting profiles at 43.5°C , expressed as the difference in molar absorbance at $\Delta\epsilon$ 283.

Feeding Practices and Carcass Quality

Beef. Sensory evaluation tests for eating quality were conducted at the Research Station, Charlottetown, on roast beef from steers fed two diets, both high in potatoes. One group was fed diets containing 100% and the other 75–80% of the levels of protein recommended by NRC (USA). Beef from

steers fed the higher protein diet was rated as superior in eating quality on the basis of odor, tenderness, and juiciness. There was no difference in flavor.

Lambs. In cooperation with the Research Station at Fredericton roast legs from lambs that were fed three different milk replacer formulations, namely, soya protein with 30% fat, soya protein with 40% fat, and milk protein with 30% fat, were compared with those from lambs nursed by the ewe. No significant differences in the intensity of lamb flavor or tenderness were noted by eight experienced judges. Shear values of the cooked meat obtained with the Warner-Bratzler shearing device were also similar for all four groups.

CEREAL AND FIELD CROPS

Oats

β -1,3-Glucanase activity. In 10 common and 11 high-protein oat cultivars examined, some of the high-protein varieties were found to be lacking in the β -glucanase activity. Hinoat and CI 4492 are two genetically unrelated varieties that are free from the activity. This has made possible the extraction of a highly viscous gum.

Chemical modifications. A refined oat flour has been modified to yield a series of oxidized, acetyl and hydroxyalkyl flours, all of which show interesting gelatinization curves. Paste viscosities and stability suggest that some of these derivatives may be suitable as thickeners in food systems.

Buckwheat

Preliminary milling studies showed that a fraction containing 40% protein can be isolated from buckwheat by conventional milling procedures.

Durum Wheat

Quality criteria for consumer acceptance of spaghetti were established. Out of the six varieties supplied by the Grain Research Laboratory, two were selected as most promising. An international collaborative study has been planned to determine the parameters for the evaluation of durum wheat and pasta quality.

Onions

Twelve varieties of onions, grown at Harrow in 1972, were evaluated for pungency and pyruvic acid content during the storage period of October to June. Threshold concentrations of aroma ranged from 6 to 43 ppm of extracted juice. Pyruvic acid content ranged from 11 to 14 μ mol/ml of juice. Pyruvic acid content reached a peak in February, which was reflected in the lower thresholds for aroma.

Eighteen onion cultivars and onions subjected to nine chemical treatments were evaluated for firmness as a criterion of quality. Firmness determined by instrumental techniques related directly to sensory evaluation.

MISCELLANEOUS

Boronate Esters of Carbohydrates

GLC response factors and retention times of butane boronate ester (BBE) derivatives of some monosaccharides were determined.

The alkali flame ionization detector was shown to be specific and sensitive for BBE. Linear responses obtained with BBE allowed quantitative analysis of mixtures of glucose and fructose; however, mixtures of fucose, arabinose, xylose, and glucose showed errors indicative of interaction between sugars. A number of benzene boronate esters and BBE were synthesized and characterized by means of IR, NMR, and mass spectrometry.

Analysis of Citrus Juices

One hundred and fifty commercial samples of concentrates and single-strength juices of orange, grapefruit, and their blends, originating from different geographical regions such as Brazil, Israel, Mexico, California, and Florida, were analyzed for free amino acids, total polyphenolic compounds, and potassium.

With a few exceptions all samples met the minimum criteria established by the Health Protection Branch of the Department of Health and Welfare.

PUBLICATIONS

Research

Durkee, A. B., and Harborne, J. B. 1973. Flavonol glycosides in *Brassica* and *Sinapis*. *Phytochemistry* 12:1085-1089.

Fejer, S. O., Johnston, F. B., and Hammill, M. M. 1973. The inheritance of ascorbic acid in red raspberry. *Can. J. Genet. & Cytol.* 15:372-375.

Greenhalgh, R., and Wood, P. J. 1973. The detection of boron and the response of some boronate derivatives of carbohydrates with an alkali flame ionization detector. *J. Chromatogr.* 82:410-414.

Kalab, M., and Harwalkar, V. R. 1973. Milk gel structure. I. Application of scanning electron microscopy to milk and other food gels. *J. Dairy Sci.* 56:835-842.

Kalab, M., Voisey, P. W., Harwalkar, V. R., and Larose, J. A. G. 1973. Heat-induced milk gels. VI. Effect of temperature on firmness in comparison with some common food gels. *J. Dairy Sci.* 56:988-993.

Larmond, E. 1973. Physical requirements for sensory testing. *Food Technol.* 27(11):28-32.

Larmond, E., Gilbert, J., and Todd, E. 1973. Temperature effect on the organoleptic quality of barbecued chickens. *Can. Inst. Food Sci. & Technol. J.* 6:29-31.

Larmond, E., and Voisey, P. W. 1973. Evaluation of spaghetti quality by a laboratory panel. *Can. Inst. Food Sci. & Technol. J.* 6:209-211.

Leslie, A. J., Summers, J. D., and Jones, J. D. 1973. Nutritive value of air-classified rapeseed fractions. *J. Anim. Sci.* 53:153-156.

McGugan, W. A., and Howsam, S. G. 1973. Silylation of microgram samples in a gas chromatography trap. *J. Chromatogr.* 82:370-372.

Moran, E. T., Larmond, E., and Somers, J. 1973. Full-fat soybeans for growing and finishing large white turkey. II. Effect on tissue fatty acids and organoleptic evaluation. *Poult. Sci.* 52:1942-1948.

Moran, E. T., Somers, J., and Larmond, E. 1973. Full-fat soybeans for growing and finishing large white turkey. I. Live performance and carcass quality. *Poult. Sci.* 52:1936-1941.

Quinn, J. R. 1973. Conversion of bovine myoglobin into multiple, charge-heterogeneous sub-fractions. *J. Food Sci.* 38:289-293.

- Quinn, J. R. 1973. The reduction of ferric myoglobin by Ampholine on acrylamide gel electrofocusing. *J. Chromatogr.* 76:520-522.
- Siddiqui, I. R., Wood, P. J., and Khanzada, G. 1973. A di-D-galactosyl-*myo*-inositol from rapeseed (*Brassica campestris*) meal. *Carbohydr. Res.* 29:255-258.
- Siddiqui, I. R., Wood, P. J., and Khanzada, G. 1973. Low molecular weight carbohydrates from rapeseed (*Brassica campestris*) meal. *J. Sci. Food & Agric.* 24:1427-1435.
- Voisey, P. W., and Larmond, E. 1973. Exploratory evaluation of instrumental techniques for measuring some textural characteristics of cooked spaghetti. *Cereal Sci. Today* 18:126-143.
- Yates, A. R. 1973. Factors affecting respiration and germination of ascospores of the food spoilage mould *Byssoschlamys nivea*. *Can. Inst. Food Sci. & Technol. J.* 6:244-247.

Miscellaneous

- Elliott, J. A., and Emmons, D. B. 1973. Pouch sediment—a market milk defect. *Mod. Dairy* 52(3):17-18.
- Emmons, D. B. 1973. Whey: pollution or utilization. *Canadex* 414.82.
- Gorrill, A. D. L., Brisson, G. J., Emmons, D. B., and St-Laurent, G. J. 1973. Artificial rearing of young lambs. *Can. Dep. Agric. Publ.* 1507. 22 pp.
- Modler, H. W., Emmons, D. B., and Savage, K. G. 1973. Integrated nationwide approach needed to solve whey disposal problem in Canada. *Mod. Dairy* 52 (11-12):9-12.

Soil Research Institute

Ottawa, Ontario

PROFESSIONAL STAFF

J. S. CLARK, B.S.A., M.Sc., Ph.D.
R. PORTEOUS

Director
Administrative Officer

Soil Resource Research

D. R. CAMERON, B.Sc., M.Sc., Ph.D.
D. S. GAMBLE, B.Sc., M.Sc., Ph.D.
K. C. IVARSON, B.Sc., M.Sc., Ph.D.

Nutrient transport systems
Metal ion – organic reactions
Microbial decomposition of organic matter

H. KODAMA, B.Sc., M.Sc., D.Sc.

Mineralogy, crystallography, and spectrochemistry

G. J. ROSS, B.S.A., M.Sc., Ph.D.
M. SCHNITZER, B.Sc. (Agr.), M.Sc., Ph.D., F.C.S.S.

Mineralogy and weathering
Structure and properties of soil humic compounds

W. J. STAPLE, B.Sc., M.Sc., Ph.D.
G. C. TOPP, B.S.A., M.S., Ph.D.
R. C. TURNER, B.S.A., M.Sc., Ph.D.
M. D. WEBBER, B.S.A., M.Sc., Ph.D.

Soil water movement
Soil water movement
Ionic equilibria in soils
Solubility equilibria in soils

Soil Conservation Research

J. GAYNOR, B.Sc., M.Sc., Ph.D.
C. G. KOWALENKO, B.S.A., M.Sc., Ph.D.
A. J. MACLEAN, B.Sc. (Agr.), M.Sc., Ph.D.
S. P. MATHUR, B.Sc., Assoc. I.A.R.I., Ph.D.
H. MORITA, B.Sc., M.Sc., Ph.D.

Waste disposal in soils
Nitrogen cycle
Metals and fertilizers
Degradation of organic pollutants
Pesticide retention by soil organic matter

S. S. SINGH, B.Sc., M.Sc., Ph.D.
F. J. SOWDEN, B.S.A., M.S.A., Ph.D.

Metals reactions
Nitrogen cycle

Soil Resource Inventory

J. H. DAY, B.S.A., M.S.A.
J. DUMANSKI, B.S.A., M.Sc., Ph.D.
B. KLOOSTERMAN, B.S.A., Ph.D.

Soil correlation—central region
Soil data bank
Soil data bank

P. G. LAJOIE, B.A., M.S.A., M.Sc.	Agronomic interpretations
M. LEVESQUE, B.S.A., M.S.A., Ph.D.	Organic soil interpretations
A. R. MACK, B.S.A., M.Sc., Ph.D.	Remote sensing
J. A. McKEAGUE, B.A., B.S.A., M.Sc., Ph.D.	Soil classification and genesis
J. L. NOWLAND, B.A., M.Sc.	Soil correlation—eastern region
J. A. SHIELDS, B.S.A., M.Sc., Ph.D.	Soil correlation—western region
G. WILSON, B.Sc., M.Sc., D.I.C.	Engineering interpretations

Newfoundland Soil Survey Unit (St. John's)

P. K. HERINGA, B.Sc., M.Sc.	Head of Unit
D. SUDOM, B.S.A., M.Sc.	Party leader

Prince Edward Island Soil Survey Unit (Charlottetown)

J. I. McDOUGALL, B.Sc., B.Sc. (Agr.)	Head of Unit
--------------------------------------	--------------

Nova Scotia Soil Survey Unit (Truro)

G. J. BEKE, B.S.A., M.Sc., Ph.D.	Head of Unit
----------------------------------	--------------

New Brunswick Soil Survey Unit (Fredericton)

K. K. LANGMAID, B.Sc., M.Sc.	Head of Unit
C. WANG, B.Sc., M.Sc., Ph.D.	Party leader

Ontario Soil Survey Unit (Guelph)

C. J. ACTON, B.S.A., M.Sc., Ph.D.	Head of Unit
B. H. CAMERON, B.Sc. (Agr.)	Party leader
J. E. GILLESPIE, B.S.A., M.S.A.	Party leader
S. E. HUMPHREY, B.Sc. (Agr.), M.Sc.	Party leader
E. W. PRESANT, B.S.A., M.Sc.	Party leader
G. J. WALL, B.S.A., Ph.D.	Party leader

Manitoba Soil Survey Unit (Winnipeg)

R. E. SMITH, B.S.A., M.Sc.	Head of Unit
W. MICHALYNA, B.S.A., M.Sc., Ph.D.	Party leader
C. TARNOCAL, B.S.F., M.S.	Party leader

Saskatchewan Soil Survey Unit (Saskatoon)

D. F. ACTON, B.S.A., M.Sc.	Head of Unit
K. W. AYRES, B.S.A.	Party leader
A. K. BALLANTYNE, B.S.A., M.Sc.	Party leader

L. S. CROSSON, B.S.A., M.Sc., Ph.D.	Party leader
W. K. JANZEN, B.S.A., M.Sc.	Party leader
H. P. W. ROSTAD, B.S.A., M.Sc., Ph.D.	Party leader
H. B. STONEHOUSE, B.S.A., M.Sc.	Party leader

Alberta Soil Survey Unit (Edmonton)

T. W. PETERS, B.Sc., M.Sc.	Head of Unit
G. M. COEN, B.Sc., M.Sc., Ph.D.	Party leader
P. H. CROWN, B.S.A., M.Sc.	Party leader
A. A. KJEARSGAARD, B.Sc.	Party leader
S. S. KOCAOGLU, B.S.	Party leader
W. W. PETTAPECE, B.S.A., M.Sc., Ph.D.	Party leader

British Columbia Soil Survey Unit (Vancouver)

T. M. LORD, B.S.A.	Acting Head of Unit
T. BEDWANY, B.S.A.	Party leader
P. CHRISTIE, B.S.A.	Party leader
L. FARSTAD, B.S.A., M.Sc.	Party leader
A. J. GREEN, B.S.A., M.Sc.	Party leader
L. A. LESKIW, B.S.A., M.Sc.	Party leader
J. I. SNEDDON, B.S.A., M.Sc.	Party leader
K. VALENTINE, B.S.A., M.Sc.	Party leader
W. WATT, B.S.A.	Party leader

Cartography

J. H. DAY, B.S.A., M.S.A.	Supervising Officer
J. G. ROBERTS	Cartographic Supervisor

Departures

J. E. BRYDON, B.Sc., M.Sc., Ph.D. Transferred to Department of the Environment, Dec. 1973	Mineralogy and weathering
S. E. HUMPHREY, B.Sc. (Agr.), M.Sc. Transferred to Ontario Department of the Environment, Sept. 1973	Ontario Soil Survey

VISITING SCIENTISTS

- S. M. GRIFFITH, B.Sc. (Agr.), M.Sc. Humic acid chemistry
CIDA Research Fellow from the University of the
West Indies at St. Augustine, Trinidad
- J. A. NEYROUD, Ing. Agr., Ph.D. Humic acid chemistry
Federal Agricultural Research Station at Lausanne,
Switzerland
- H. PÉZERAT, D.Sc. Crystal chemistry
Laboratoire de Chimie des Solides, C.N.R.S.
associated with Université de Paris

INTRODUCTION

During the year the activities of the Soil Research Institute have been marked by advances in computerized cartography of soils and development of the soil data system, by elucidation of the history and distribution of mudflow slides in the St. Lawrence Lowland, and by improved understanding of waste management systems in soils.

These advances were founded on basic research into the chemistry, physics, biology, mineralogy, and geography of soils.

The regional Soil Survey units have continued work in regular soil survey programs, with emphasis on the more detailed information required for urban planning. There was also an increased demand for work in the far north, on Indian reserves and in national parks.

Reprints of published papers are available from the authors. Correspondence should be addressed: Soil Research Institute, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

J. S. Clark
Director

SOIL RESOURCE RESEARCH

The soil resource research group is doing essential basic work on the chemistry, mineralogy, biology, and physics of the major soil components, that is, organic matter, clay minerals, and hydrous metal oxides, and on the nature of the interactions between the principal soil components. A more adequate understanding of these processes is of the utmost importance for long-term management of the soil resource for agriculture and for the maintenance of soil quality.

Work during 1973 has been concerned with the chemical structure of humic and fulvic acids and their reactions with metal ions and clays; characteristics of hydroxyaluminum polynuclear cations; weathering reactions of clay minerals and studies of phyllosilicates by diffuse X-ray scattering; reactions of phosphorus in soils with special emphasis on the formation of amorphous aluminum hydroxide phosphates in interlayers of Wyoming bentonite; survival and ability of bacteria, actinomycetes, cytophaga, and fungi to promote decomposition at low temperatures such as those found in the Northwest Territories; and measurement of moisture tension and conductivity in soils and the uses of such measurement. Progress has been good and the work has contributed significantly to a better understanding of selected chemical, biological, and physical processes in soils. During 1973 workers of this group have published 17 scientific papers, submitted 14 more for publication, and are preparing 5 others.

In response to current land and soil problems, Dr. Webber has cooperated extensively with Dr. Gaynor in work on sewage sludge with emphasis on the solubility of sludge metals in soils and how this affects plant growth. Dr. Topp is assisting the Pedology group with the development of physical measurements for use in soil classification.

SOIL CONSERVATION RESEARCH

Nutrients (PO_4 , NO_3 , and NH_3) were monitored in water from tile drains and other sources at the Greenbelt Farm of the Animal Research Institute, and in plots that received animal manure at the Central Experimental Farm. Background levels in the latter were low. A report on the agricultural contribution of nutrients to lakes Erie and Ontario was completed and formed part of the Task Force Report of Canada Department of Agriculture.

Sewage sludges from industrial areas in Ontario were found to contain considerable quantities of trace metals. The extractability and uptake of metals by plants in sewage-treated soils were investigated. Sewage added to a sandy soil increased the amounts of Zn, Cu, and Pb in lettuce grown in the soil, but a clay soil retained more of the metals.

Experiments on the effect of soil properties and amendments on the availability of Zn in soils were completed and a manuscript was submitted for publication. Further work on retention of Hg by soils is nearing completion. Exploratory experiments have shown

that Cd is precipitated as amorphous cadmium hydroxy salts, the composition being dependent on the nature of the anion present. With passage of reaction time, cadmium carbonate was precipitated under neutral and alkaline conditions.

Further experiments were conducted on establishment of vegetation on mine tailings. Analyses of plants and tailings for nutrients and toxic metals are in progress.

A study was initiated on the absorption of the weed killer linuron by organic soils. A spectrophotometric method was needed to detect linuron at concentrations of 100 ng/ml; one was developed as an interim routine procedure and is now being applied to a variety of organic soils. Some of the strongly acidic phenolpolycarboxylic acids derived from Humisols and identified in previous work were found to form water-soluble complexes with linuron. This suggests a mechanism whereby such a chemical leaches from organic soils.

In other studies, it was found that a polyaromatic hydrocarbon was not readily degraded in soils. Polyaromatic hydrocarbons, some of which are carcinogenic, may be produced by burning wastes (such as gases in soil fields, or stubble). The lipid fractions of seeds (rape, flax, and wheat) harvested from soil contaminated with such a hydrocarbon (benzanthracene) tended to contain above-normal amounts of the chemical. Some attention was given to another nonagricultural pollutant, phthalic acid esters. Unequivocal evidence was obtained that they are degraded by certain mesophilic soil microorganisms.

No requests were received for major involvement of Soil Research Institute staff in crop management programs, and no independent studies of any magnitude were carried out.

Cooperative work on effects of soil temperature on corn growth were completed and staff continued to participate, though in a minor capacity, in studies at the research establishments at Ottawa, Kapuskasing, and other locations.

SOIL RESOURCE INVENTORY

The main objective of the soil resource inventory program, in conjunction with the program of the soil survey units throughout

Canada, is to acquire and correlate information on the nature, distribution, and capability of the soil resources of Canada. Also, the soil resource is evaluated in terms of land use planning at both broad and detailed scales. In 1973, Dr. Wilson (engineering interpretations), Dr. Kloosterman (data bank), and Mr. Nowland (eastern correlator) joined the staff at Ottawa.

Marked progress was made in interpretations of soil resource information: agricultural capability maps at a scale of 1:1,000,000 were completed for six provinces, and areas of the various classes and subclasses were calculated; the suitability of Nova Scotia soils for septic disposal systems was evaluated; the impact of a proposed development plan on soils suitable for special crops in the Niagara area was assessed; mudflow slides in the Ottawa-St. Lawrence valleys were identified and mapped; preliminary studies were made of the attrition of agricultural land by urban use in the Atlantic provinces; and engineering interpretations were improved.

CanSIS (a soil data storage and retrieval system) is now operating in an experimental mode; the system is accepting morphological, analytical, and interpretive data on soils and providing rudimentary outputs such as soil profile descriptions, a list of soil names, and basic and interpretive soil maps. Because of the requirements of the data system, soil descriptions throughout the country are achieving a higher degree of compatibility. Correlation of soil mapping and classification has proceeded in all regions and adherence to national standards is increasing.

In the area of soil classification, the classification of Podzolic soils was refined and an improved system for classifying soils with permafrost was developed.

In soil characterization and genesis, the nature of cemented horizons in soils of British Columbia was studied, work on the absorptive properties of organic soils was started, and progress was made in developing a method for measuring soil hydraulic conductivity rapidly in the field.

Imagery from the earth resources telemetry satellite (ERTS) and from aircraft was evaluated for the identification of crops and of land use patterns in several regions of the country. In the area of Melfort, Sask., crops were identified successfully from both aircraft and satellite imagery.

On the international level an evaluation of soil degradation in Canada was started as part of an FAO project, a soil survey feasibility study was made in Sarawak, and members of the group participated in international meetings on soil micromorphology and on organic soils.

A survey of the National Capital Region was started to provide soil resource information essential to land use planning.

Background levels of mercury were determined in more than 200 soil samples from widely distributed regions of Canada. The levels of 12 other elements in these samples are being determined.

The resource inventory of soils in the agricultural regions of Canada continued in 1973, and there was a growing demand for more detailed resource information required for urban planning. Expansion of the field mapping programs into wilderness areas accelerated, further widening the scope of soil survey activities. Requests were serviced from the Geological Survey of Canada for work in the far north and from the Department of Indian and Northern Affairs for work on Indian reserves and national parks. Requests from provincial and federal departments of forestry were also serviced.

Soil Surveys

The soil survey activities within each province are summarized below. The man-years (m.y.) of work reported for this program include the time of federal, provincial, and university personnel.

Newfoundland Soil Survey. The field program focused on exploratory survey of the Bonavista Peninsula (2C) and Port-aux-Basques - Stephenville areas, to prepare a soil inventory and rating of capability for agriculture at an exploratory scale (1:250,000). Helicopter transport was used for the first time. The inventory used 1.7 m.y.

Prince Edward Island Soil Survey. Approximately one-third of the island was surveyed at a scale of 1:12,000, and about one-third remains to be surveyed. The sampling, analytical, and canSIS-input operations are well advanced but preparation of the soil map awaits completion of the survey. Active input is needed into specialized surveys, soil erosion control, and land use planning. The inventory took 5.8 m.y.

Nova Scotia Soil Survey. Field survey work was done in Colchester County by the newly appointed surveyor, G. Beke, under the tutelage of J. Nowland. Six soil surveys are now out of print. One m.y. was devoted to the program. J. Nowland transferred to Ottawa in July.

New Brunswick Soil Survey. Field surveys were conducted in the areas of Minto-Harcourt-Buctouche and Richibucto-Rogersville, provincial parks, and farm planning areas. Input of about 80 profiles into CanSIS has been completed. The inventory program used 3 m.y.

Quebec Soil Survey. Field surveys started in the counties of Arthabaska, Wolfe, Frontenac, Mégantic, and Beauce near the end of the field season. The field work in Témiscouata is being checked. Surveys of Ile d'Orléans, Ile-aux-Coudres, and Ile-aux-Grues have been suspended in the temporary absence of R. Marcoux. Projects in Portneuf, Charlevoix, and Dorchester counties are nearing completion. An exploratory survey in the James Bay region, conducted by Environment Canada, covered 7.8 million ha (19.2 million ac).

Ontario Soil Survey. Field surveys are being conducted in Middlesex, Brant, and Carleton counties. All these detailed (1:20,000 or 1:25,000) surveys are being compiled on photographic bases. An inventory was conducted in Pukaskwa National Park for purposes of park planning and management. The staff is again at full strength with the return of G. W. Wall and E. W. Presant. The inventory program took 4.5 m.y.

Manitoba Soil Survey. Surveys are at various stages in the areas of Roseau River Basin, Winnipeg Region, Grand Rapids, The Pas, Swan Lake, Cormorant Lake, Wekusko, Cross Lake - Norway House, and Pointe du Bois. Reports are being prepared for the areas of Red Rose - Washaw Bay, Ste. Rose du Lac, Waterhen, Virden, and Morden-Winkler. The inventory program took 6.5 m.y. G. Beke transferred to Truro in midyear.

Saskatchewan Soil Survey. Reports are in preparation for the areas of Saskatoon and Hudson Bay - Swan Lake, and six areas within the Northern Provincial Forest. Field surveys are being conducted in the Swift Current and Weyburn areas. Supportive

studies were carried out on remote sensing, forest fertility, carbonate mineralogy, salinity, and soil physical properties. Ten man-years were devoted to the inventory programs and supportive studies. B. Stonehouse was seconded to CIDA for a 2-yr assignment in Tanzania; his position is being filled by G. Padbury. H. Rostad returned from educational leave.

Alberta Soil Survey. Surveys were conducted in Two Hills County, eight provincial parks, Wapiti area, Edmonton urban area, Oyen area, and Yoho and Revelstoke national parks. Reports were completed or are in preparation for Sand River area, Waterton Lakes Park, Suffield Military Reserve, Tawatinaw area, and Medicine Hat area. The inventory project used 10.5 m.y., and 2.5 m.y. were devoted to supportive research investigations including remote sensing and yield studies.

British Columbia Soil Survey. Surveys were conducted in the Stikine River region outside the ARDA boundary, in the Alberni area, Omineca-Parsnip area, Kluskus area, Indian reserves, Victoria capital regional district, Chilliwack provincial forest, and Fort George area. Reports are in various stages of preparation for the areas of Ashcroft, Lardeau, Seymour Arm, Penticton, Nelson, Taseko Lakes, Tulameen, Princeton, and Merritt.

Mr. Leskiu left the service in September and Dr. Valentine returned from educational leave in October. In total, 25 m.y. were devoted to the inventory program.

Northwest Territories. Much of the field program took place along the Mackenzie

Valley to the Beaufort Sea and on the north slope of the Yukon and Tuktoyaktuk Peninsula. Environmental geology was also evaluated in the Kaminak Lake area and soils were investigated on Melville and Devon islands.

Liaison continued with cooperating agencies in the Mackenzie Valley transportation corridor, and staff became involved with the environmental social program to assess environmental impact. Recommendations were made on the effects of cryoturbation, moisture, and near-surface ice content on pipeline, road, and other construction. Terrain instability as a result of forest fires was also investigated.

Pedological studies were conducted on permanently frozen soils under various vegetative covers and surficial materials, and at different elevations above sea level. After a 1-wk correlation tour in the Inuvik area, the classification scheme proposed at the meetings of the Canadian Soil Survey Committee was somewhat modified.

CARTOGRAPHY

In 1973 the Cartography Section completed drafting 17 soil and miscellaneous maps, 11 maps were in press, and 14 maps were printed; 36 soil maps and 10 miscellaneous maps are in preparation.

The Cartography Section also completed drafting 218 maps for the Canada Land Inventory; 60 maps were in press, and 105 maps were published.

Cartographic and photomechanical services were provided to soil survey units in the provinces and to CanSIS, remote sensing, the Economics Branch, the Minister's office, and others.

AREAS SURVEYED IN 1973, BY PROVINCE AND BY OBJECTIVE

	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	Nfld.	NWT & YT	TOTAL
Soil surveys — thousands of hectares												
New surveys*												
Reconn.	1973	7,337	526	—	182	—	51	—	—	—	—	8,096
	Total	42,117	27,333	18,967	15,149	7,323	4,440	5,372	595	1,266	3,707	154,387
Detailed	1973	4	87	—	—	—	1.6	—	—	—	—	91.6
	Total	41.8	1,794	—	—	5.3	19.3	—	—	—	17	1,877
Explor.	1973	—	—	—	—	7,770	—	—	—	1,243	—	9,013
	Total	2,630	41,386	4,470	5,684	7,859	—	—	—	1,243	24,929	99,128
Resurveys*												
Reconn.	1973	959	130	404	13	—	—	4	—	—	—	1,510
	Total	3,761	761	18,720	423	334	28	559	—	—	—	25,062
Detailed	1973	—	—	—	71	45	—	—	202	—	—	318
	Total	366	0.1	2,078	827	520	0.1	34	404	—	—	4,230
Canada Land Inventory — thousands of hectares												
Agriculture	1973	7,329	—	—	—	—	—	—	—	1,244	—	8,572
— new	Total	37,798	43,301	35,987	20,542	20,905	30,236	7,116	5,372	2,509	3,529	207,862
— reassess.	1973	1,242	—	—	—	—	—	—	—	—	—	1,242
	Total	3,237	—	1,756	227	332	—	—	—	—	—	5,553

*Reconnaissance at scale 1:50,000 to 1:126,720, detailed at scale of less than 1:50,000, and exploratory at scale greater than 1:125,000.

PUBLICATIONS

Research

- Baier, W., and Mack, A. R. 1973. Development of soil temperature and soil water criteria for characterizing soil climates in Canada. *Soil Sci. Soc. Am. Proc.* 37:195-212.
- Baier, W., Sharp, W. R., and Roberts, J. G. 1973. Recent developments in preparing colored agroclimatic maps by computer. *Can. J. Soil Sci.* 53:133-134.
- Beke, G. J., Weldhuis, H., and Thie, J. 1973. Biophysical investigations of the Churchill-Nelson River System. Rep. to Churchill-Nelson River Study Board. 409 pp., 10 maps.
- Brandon, E., and Kloosterman, B., eds. 1973. CanSIS: Documentation of the soil cartographic file. Agriculture Canada, Ottawa. 180 pp.
- Brewer, R., Protz, R., and McKeague, J. A. 1973. Microscopy and electron microprobe analysis of some iron-manganese pans from Newfoundland. *Can. J. Soil Sci.* 53:349-361.
- Coen, C. M. 1973. Elimination of magnesium hydroxide interference in infrared identification of kaolinite in soil clays. *Can. J. Soil Sci.* 53:137-140.
- Cordukes, W. E., and MacLean, A. J. 1973. Tolerance of some turfgrass species to different concentrations of salt in soils. *Can. J. Plant Sci.* 53:69-73.
- Dumanski, J., and Kloosterman, B., eds. 1973. Soil site coding scheme for data input to the soil data file of the Canada Soil Information System (CanSIS). 3rd Rev. Agriculture Canada, Ottawa. 52 pp.
- Dumanski, J., and Kloosterman, B., eds. 1973. Coding scheme for data input to the agricultural small-plot subfile of the performance/management file: Canada Soil Information System (CanSIS). 1st Draft. Agriculture Canada, Ottawa. 36 pp.
- Dumanski, J., Macyk, T. M., Lindsay, J. D., and Veauvy, C. 1973. Soil survey and land evaluation in the Hinton-Edson area, Alberta. *Alta. Soil Surv. Rep.* 32, *Alta. Inst. Pedol.*, Edmonton. 150 pp.
- Gamble, D. S. 1973. Na^+ and K^+ binding by fulvic acid. *Can. J. Chem.* 51:3217-3222.
- Gamble, D. S., and Schnitzer, M. 1973. The chemistry of fulvic acid and its reactions with metal ions. *Trace Met. & Met.-Org. Interactions in Nat. Waters* 9:265-302.
- Ivarson, K. C. 1973. Microbiological formation of basic ferric sulfates. *Can. J. Soil Sci.* 53:315-323.
- Kloosterman, B. 1973. CanSIS: Digitizing procedure for data input to the cartographic file. (Rev.). Can. Dep. Agric., Ottawa. 12 pp.
- Kloosterman, B., and Lavkulich, L. M. 1973. A method of statistically interpreting soil data for agriculture and engineering land use. *Soil Sci. Soc. Am. Proc.* 37:285-290.
- Kloosterman, B., and Lavkulich, L. M. 1973. Grouping of lower Fraser Valley soils by numerical methods. *Can. J. Soil Sci.* 53:435-444.
- Kodama, H., and Schnitzer, M. 1973. Dissolution of chlorite minerals by fulvic acid. *Can. J. Soil Sci.* 53:240-243.
- Kowalenko, C. G., and Lowe, L. E. 1973. Determination of nitrates in soil extracts. *Soil Sci. Soc. Am. Proc.* 37:660.
- Levesque, M. 1972. Fluorescence and gel filtration of humic compounds. *Soil Sci.* 113:346-353.
- Mack, A. R. 1973. Soil temperature and moisture conditions in relation to the growth and quality of field peas. *Can. J. Soil Sci.* 53:59-72.
- Mack, A. R. 1973. Symposium of field soil moisture regimes. *Soil Sci. Soc. Am. Proc. Spec. Publ.* 5, Ch. 11, pp. 195-212.
- Mack, A. R. 1973. Influence of soil temperature and moisture conditions on growth and protein production of Manitou and two semi-dwarf Mexican spring wheats. *Can. J. Plant Sci.* 53:721-735.
- Mack, A. R., and Bowren, K. E. 1973. Crop identification and acreage estimates from airborne and satellite photographs for an area in northeastern Saskatchewan. Paper presented at the Agric. Work. Group on Remote Sensing, Saskatoon.
- MacLean, A. J., and Donovan, L. S. 1973. Effects of soil temperature on early growth of six single-cross corn hybrids. *Can. J. Soil Sci.* 53:128-129.
- MacLean, A. J., and MacDonald, E. M. 1973. Agricultural contributions to nutrient enrichment of waters in watersheds of Lake Erie, Lake Ontario and the Intern'l Section of the St. Lawrence River. 107 pp. Part of CDA Task Force Rep. for implementation of Great Lakes water quality program. *Soil Res. Inst.*, Ottawa, Ont.

- MacLean, A. J., Stone, B., and Cordukes, W. E. 1973. Amounts of mercury in soil of some golf course sites. *Can. J. Soil Sci.* 53:130-132.
- McKeague, A. J., Day, J. H., and Clayton, J. S. 1972. Properties and development of hydromorphic mineral soils in various regions of Canada. Pages 207-218 in E. Schlichting and V. Schwertmann, eds. *Pseudogley and Gley*. Trans. Comm. 5 and 7, Int. Soc. Soil Sci. Verlag Chemie, Germany.
- Mathur, S. P. 1973. The determination of quinone groups in humic substances. *Soil Sci. Soc. Am. Proc.* 37:487-488.
- Mathur, S. P. 1973. Quinone content of humic compounds isolated from the marine environment. A criticism. *Soil Sci.* 115:89-90.
- McKeague, J. A., Dumanski, J., and Acton, C. J. 1973. Soil micromorphology in Canada. *Proc. 4th Int. Work. Meet. on Soil Micromorphology*, Kingston, Ont.
- McKeague, J. A., MacDougall, J. I., and Miles, N. M. 1973. Micromorphological, physical, chemical, and mineralogical properties of a catena of soils from Prince Edward Island in relation to their classification and genesis. *Can. J. Soil Sci.* 53:281-295.
- Morita, H. 1973. Vanillin derivatives from a copper peat. *Can. J. Soil Sci.* 53:85-86.
- Morita, H. 1973. Polyphenols in the benzene-ethanol extractives of an organic soil. *Geochim. Cosmochim. Acta* 37:1587-1591.
- Ortiz de Serra, M. I., and Schnitzer, M. 1973. The chemistry of humic and fulvic acids extracted from Argentine soils. I. Analytical characteristics. *Soil Biol. Biochem.* 5:281-286.
- Ortiz de Serra, M. I., and Schnitzer, M. 1973. The chemistry of humic and fulvic acids extracted from Argentine soils. II. Permanganate oxidation of methylated humic and fulvic acids. *Soil Biol. Biochem.* 5:287-296.
- Ortiz de Serra, M. I., Sowden, F. J., and Schnitzer, M. 1973. Distribution of nitrogen in fungal "humic acids." *Can. J. Soil Sci.* 53:125-127.
- Pawluk, S., and Dumanski, J. 1973. Ferruginous concretions in a poorly drained soil of Alberta. *Soil Sci. Soc. Am. Proc.* 37:124-127.
- Riffaldi, R., and Schnitzer, M. 1973. Effects of 6 N HCl hydrolysis on the analytical characteristics and chemical structure of humic acids. *Soil Sci.* 115:349-356.
- Ross, G. J., and Rich, C. I. 1973. Effect of particle thickness on potassium exchange in phlogopites. *Clays & Clay Miner.* 21:77-81.
- Ross, G. J., and Rich, C. I. 1973. Effect of particle size on potassium sorption by potassium depleted phlogopite. *Clays & Clay Miner.* 21:83-87.
- Ross, G. J., and Rich, C. I. 1973. Changes in *b*-dimension in relation to potassium exchange and to oxidation of phlogopite and biotite. *Clays & Clay Miner.* 21:201-204.
- Schnitzer, M. 1973. The determination of quinone groups in humic substances. *Soil Sci. Soc. Am. Proc.* 37:487-488.
- Schnitzer, M., and Khan, S. U. 1972. *Humic substances in the environment*. Marcel Dekker Inc., New York. 327 pp.
- Schnitzer, M., and Ortiz de Serra, M. I. 1973. The sodium-amalgam reduction of soil and fungal humic substances. *Geoderma* 9:119-128.
- Schnitzer, M., and Ortiz de Serra, M. I. 1973. The chemical degradation of a humic acid. *Can. J. Chem.* 51:1554-1556.
- Schnitzer, M., Ortiz de Serra, M. I., and Ivarson, K. 1973. The chemistry of fungal humic acid-like polymers and of soil humic acids. *Soil Sci. Soc. Am. Proc.* 37:229-236.
- Shields, J. A., and Paul, E. A. 1973. Decomposition of ¹⁴C-labelled plant material under field conditions. *Can. J. Soil Sci.* 53:297-306.
- Singh, S. S., and Halstead, R. L. 1973. A report on Spartan apple breakdown in Okanagan Valley, B.C. *Soil Res. Inst., Ottawa, Ont.* 37 pp.
- Tarnocai, C. 1973. Soils of the Mackenzie River area. Environmental Social Program, Northern Pipelines, Task Force on Northern Oil Development. Rep. No. 73-4, 105 pp.
- Teller, H. L., and Cameron, D. R. 1973. Disposition and environmental effects of silver iodide from cloud seeding. Terrestrial disposition in silver. In *San Juan Ecology, Project Rep.*, Colo. State Univ., Ft. Collins, Colo.
- Volk, G. B., and Schnitzer, M. 1973. Chemicals and spectroscopic methods for assessing subsidence in Florida Histosols. *Soil Sci. Soc. Am. Proc.* 37:886-888.
- Wang, C., and Wood, F. A. 1973. A modified aluminon reagent for the determination of aluminum after HNO₃-H₂SO₄ digestion. *Can. J. Soil Sci.* 53:237-239.
- Zoltai, S. C., and Pettapiece, W. W. 1973. Terrain, vegetation and permafrost relationships in the northern part of the MacKenzie Valley and northern Yukon. Environmental Social Program, Northern Pipelines, Task Force on Northern Oil Development Rep. No. 73-4. 105 pp.

Miscellaneous

- Day, J. H., ed. 1973. Revised system of soil classification for Canada: a provisional correction of official and tentative definitions for use by Canadian pedologists. Can. Dep. Agric., Soil Res. Inst., Ottawa. Mimeo.
- Day, J. H., and Dumanski, J. 1973. CanSIS soil names file. Soil Res. Inst., Ottawa.
- Day, J. H., and Kloosterman, B. 1973. CanSIS soil names file (rev.). Soil Res. Inst., Ottawa.
- Day, J. H., and Lajoie, P. J., eds. 1973. Proceedings of the 9th Meeting, Can. Soil Surv. Comm. Univ. of Saskatchewan, Saskatoon, Sask., May 16-18, 1973.
- Subcommittee reports:*
- Lajoie, P. G. Provincial soil and interpretation maps. pp. 18-24.
- Shields, J. A. Soil degradation. pp. 35-42.
- Dumanski, J., and Kloosterman, B. CanSIS. pp. 43-85.
- Roberts, J. G., and Norgren, R. Cartographic services. pp. 86-95.
- Tarnocai, C., Pettapiece, W. W., and Zoltai, S. C. Northern soils. pp. 96-116.
- Acton, D. F. Landform classification. pp. 117-135.
- Tarnocai, C. Remote sensing. pp. 155-164.
- Acton, C. Soil interpretations. pp. 165-190.
- Nowland, J. L. Soil families. pp. 191-208.
- McKeague, J. A. Methods of analysis and benchmark soils. pp. 209-214.
- Ellis, J. G. Miscellaneous land types. pp. 215-230.
- Day, J. H. Soil climate. pp. 231-238.
- Sly, W. K. Soil temperature. pp. 239-248.
- Peters, T. W. Solonchic order. pp. 254-261.
- Shields, J. A. Luvisolic soils. pp. 262-272.
- McKeague, J. A., and Shields, J. A. Podzolic order. pp. 273-293.
- McKeague, J. A. Brunisolic order. pp. 294-304.
- Rocheport, B. Regosolic order. pp. 305-308.
- Smith, R. E. Gleysolic order. pp. 309-320.
- Day, J. H. Organic order. pp. 321-329.
- Lindsay, J. D. Soil horizons. pp. 330-339.
- Kodama, H. 1973. The 10th Meeting of Clay Minerals. J. Clay Sci. Soc. Japan, Vol. 13.
- Mack, A. R. 1973. What's up in the air for remote sensing? Can. Agric. 18(3):22.
- Philpotts, L. E., and Mack, A. R. 1973. Bibliography on applications of remote sensing and aerial photography to agricultural crops, soil resources and land use. Soil Res. Inst., Ottawa, Ont. pp. 1-41.
- Tarnocai, C., and Beke, G. J. 1973. Application of remote sensing techniques to resource inventories. Can. Agric. 18(2):14-17.

Research Institute London, Ontario

PROFESSIONAL STAFF

Administration

E. Y. SPENCER, B.Sc., Ph.D., F.C.I.C.	Director
M. VAN YSSELSTEIN, B.Sc.	Administrative Officer
V. NATHAN (Mrs.), B.Sc., M.L.S.	Librarian

Herbicides and Growth Regulators

T. T. LEE, B.Sc., Ph.D.	Plant biochemistry and tissue culture
W. H. MINSHALL, B.S.A., M.Sc., Ph.D.	Plant physiology
E. B. ROSLYCKY, B.S., M.Sc., Ph.D.	Microbiology

Mode of Action of Selected and Potential Insect Control Agents

W. CHEFURKA, B.Sc., M.Sc., Ph.D.	Biochemistry
E. J. BOND, B.S.A., M.Sc., Ph.D.	Fumigation: toxicology
B. E. BROWN, B.Sc., M.Sc., Ph.D.	Neurochemistry
T. DUMAS, D.C.E., M.Sc.	Analytical chemistry
C. L. HANNAY, B.S.A., Ph.D.	Electron microscopy: cytology
R. M. KRUPKA B.A., M.A., Ph.D.	Biochemistry
D. G. R. MCLEOD, B.S.A., M.S., Ph.D.	Physiology
T. NAGAI, M.E., M.Sc., D.Sc.	Neurophysiology
J. R. ROBINSON, B.S.A., M.S.A., Ph.D., F.C.I.C.	Chemistry: radioisotopes
A. N. STARRATT, B.Sc., Ph.D., F.C.I.C.	Chemistry: attractants and repellents
A. VARDANIS, B.Sc., M.Sc., Ph.D.	Biochemistry

Soil Insecticide Behavior

C. R. HARRIS, B.A., M.A., Ph.D.	Insect toxicology
B. T. BOWMAN, B.S.A., Ph.D.	Soil physical chemistry
R. A. CHAPMAN, B.Sc., M.Sc., Ph.D.	Analytical organic chemistry

J. R. W. MILES, B.Sc.
 H. H. SVEC, Dipl. Agr.
 A. D. TOMLIN, B.A., M.Sc., Ph.D.
 C. M. TU, B.Sc., M.Sc., Ph.D.

Analytical chemistry
 Applied entomology
 Pesticide ecology
 Microbiology

Mode of Action of Selected and Potential Plant Pathogen Control Agents

E. W. B. WARD, B.Sc., M.Sc., Ph.D.

Plant pathology: phytoalexins and toxins

D. M. MILLER, B.Sc., M.Sc., Ph.D.

Biophysical chemistry: fungicide selectivity

L. T. RICHARDSON, B.A., M.A., Ph.D.

Plant pathology: fungicides

A. STOESSL, B.Sc., Ph.D., F.C.I.C.

Organic chemistry: phytoalexins and toxins

G. D. THORN, B.Sc., M.A., Ph.D., F.C.I.C.

Organic chemistry: fungicides

G. A. WHITE, B.A., M.Sc., Ph.D.

Biochemistry: fungicides

VISITING SCIENTISTS

National Research Council postdoctorate fellows

D. R. JONES, B.Sc., Ph.D., 1973

Plant pathology

J. H. TOLMAN, B.Sc., Ph.D., 1973

Entomology: toxicology

Graduate students

K. P. KASHI, B.Sc., M.Sc., 1970

Fumigation

J. FUNG, B.Sc., M.Sc., 1971

Biophysics: selective transport

INTRODUCTION

The highlights of the Institute's research activities for 1973 are summarized here. The activities include studies on the mode of action and use of toxicants (fungicides, herbicides, and insecticides); the search for new target sites; and the isolation and characterization of biologically active material such as phytoalexins, insect neurotransmitters, and insect attractants and repellents that may have potential for use in crop protection. Concurrently, ecological and environmental studies aim to assist in reducing any deleterious side effects to a minimum.

This report and reprints of publications are available on request from the Research Institute, Research Branch, Agriculture Canada, University Sub Post Office, London, Ont. N6A 3K0.

E. Y. Spencer
Director

PLANT PESTS

Mode of Action of Selected and Potential Insect-control Agents

Our contribution to the development of a more efficient pest-control program with the use of chemicals is being made in two ways: by studying the action of selected agents that are known to be pesticides or may be potential pesticides; and by improving our understanding of sites in biological systems attacked by chemicals, which will lead to improved pesticides design resulting in higher toxicity and greater selectivity.

The toxicity of benomyl to earthworms was shown to be related to the powerful anticholinesterase activity of butyl isocyanate, a decomposition product of benomyl. The mechanism of interaction between this isocyanate and cholinesterase suggests the possibility of finding N-substituted isocyanates that may be strong inhibitors of cholinesterase and therefore pesticides.

Certain biodegradable analogues of DDT were found to be potent inhibitors of membrane-linked enzymes, which mediate translocation of organic anions. These toxicants were somewhat more inhibitory than DDT and heptachlor and vastly more inhibitory than dieldrin. DDT also inhibited the movement of cations across mitochondrial membranes in a manner similar to that of nerve. This effect has only been demonstrated in preparations from liver.

The new neurotransmitter substance, proctolin, has been found in several species of economic importance, and its chemical structure has been established as a pentapeptide.

Chemical synthesis of proctolin and its analogues is in progress.

An in vitro system of synthesizing chitin has been developed. The procedure consists of a whole-cell preparation from both the migratory locust, *Locusta migratoria*, and the migratory grasshopper, *Melanoplus sanguinipes*. Standard activities are high, and chitin synthesis by this system is inhibited by polyoxins, antifungal agents.

A cytological examination of cellular cycles during the metamorphosis of the corn borer was made in order to pinpoint the correct time for testing the mode of action of compounds chemically or biologically related to natural hormones and to possibly locate target sites.

Methods have been established for studying the metabolism of some vinyl phosphate insecticides in relation to their selective toxicity. Toxic crystal inclusions of different strains of *Bacillus thuringiensis* varying in toxicity have been produced in preparation for studying the basis of this toxicity variation.

In the program of isolation and chemical characterization of substances influencing insect behavior for ultimate control, the investigation of the oviposition pheromone of the mosquito *Culex tarsalis* was continued, and the identification of the major 1,3-diglyceride fraction from eggs of two related species completed. The crystalline compound obtained from cultures of *Nigrospora sphaerica*, during a study of aggregation of the confused flour beetle, has been identified as aphidicolin, an antiviral diterpene.

Fumigants—Mode of Action, Use, and Residue Analysis

New information has been obtained on the resistance of insects to fumigants; the development and improvement of methods for controlling insects on fruit, vegetables, and other stored products over a range of temperatures; the toxicology of fumigants; and the formation of residues. The development of resistance to fumigants is a worldwide problem of increasing concern to those who are responsible for protecting stored food from insects. Our studies have shown that at least four species of insect pests of stored products can develop resistance to fumigants. Selection of the red flour beetle with ethylene dibromide has produced more than fourfold resistance in six generations, and tolerance is expected to increase with continued selection. Selection of adult granary weevils with methyl bromide has produced a strain that is 17 times more resistant than the normal strain. A study of the premature stages has shown that some degree of resistance also occurs in them. Studies on a phosphine-resistant strain of granary weevil have shown that when adults are in the stage used for selection some resistance may occur in the pupal stage but other immature stages do not possess the tolerant characteristic. Control of insects with fumigants at low temperatures is difficult. Studies on the manipulation of environmental conditions have shown that insects can be controlled more effectively by raising the temperature during fumigation, and these insects are more susceptible than insects conditioned at the higher temperature. Preliminary results with mixtures of fumigants have shown that some mixtures are more effective than a single fumigant at low temperatures and suggest that further improvement in control measures is possible. Tests on a method for controlling the European corn borer and the cereal leaf beetle on corn have shown that methyl bromide used at the level recommended may slightly injure the husks, stimulate germination of the seeds, encourage growth of molds, and bleach some kernels. However, the residue of inorganic bromide left in the corn is within the permitted tolerance levels.

In studies on the toxic action of fumigants, one of the target sites for phosphine was identified as cytochrome oxidase. The heme part of the molecule is altered by phosphine, but the protein conformation is unchanged

and the copper component is not affected. Carbon dioxide, which enhances the toxicity of phosphine, has been shown to affect phosphorylation, whereas phosphine inhibits electron transport. One of the degradation products of phosphine has an excitatory effect on visceral muscle.

Soil Insecticides—Ecological and Chemical Behavior

Twelve species (20 strains) of insects were observed. The rearing of lepidopterous strains of insects was difficult because of a microsporidian infection. Laboratory studies indicated that the corn rootworm is showing tolerance for chlordane in Ontario, the Colorado potato beetle tolerance for endosulfan, and the onion maggot tolerance for many organophosphorus and carbamate insecticides.

Studies on the mechanisms by which insecticides are bound to mineral soil were continued with the use of fensulfothion as the model. Bioassay studies confirmed previous work, which indicated that the cation content of soil, especially Fe^{+++} and Al^{+++} , influences the extent to which some insecticides are inactivated in soil.

Toxicological and chemical studies on insecticide behavior, persistence, and degradation in both the laboratory and field were closely coordinated. Studies are in progress on nearly all important organophosphorus soil insecticides, including fensulfothion, phorate, Counter (American Cyanamid), leptophos, chlorpyrifos, and methyl chlorpyrifos. It has been established that fensulfothion degrades to the sulfone in soil, and that phorate degrades to the sulfoxide and sulfone. All sulfoxides and sulfones are insecticidal and more persistent than the parent materials.

In entomological studies, microplot and large-scale field trials (in cooperation with the federal research establishments at Vineland Station, St. Jean, and L'Assomption, and the provincial stations at Simcoe and Guelph) were conducted, and effective measures were found for control of cutworms on tobacco and vegetables, the carrot weevil, and the common armyworm.

In studies on the effects of insecticide residues on nontarget soil organisms, laboratory and field studies (in cooperation with the research stations at Delhi and Vineland Station) indicated that some nematicides had

temporary effects on soil microorganisms and microbial activities. In the development of a standardized technique for screening potential soil insecticides for their effects on soil microorganisms and microbial activities, the toxicity of six insecticides and a fungicide to earthworm populations in a trefoil pasture was determined. Some of the insecticides and the fungicide benomyl were highly toxic to earthworms. The toxicity of a number of insecticides to beneficial soil animals (Collembola and Carabidae) was evaluated in the laboratory. Results of the program to date suggest that some insecticides are less toxic to certain nontarget soil organisms than was originally believed; the converse is also true.

In a study on the effects of soil organisms on insecticides, under anaerobic conditions soil microorganisms rapidly degraded DDT to DDD. The formation of DDE from DDT in soil appears to be primarily due to its metabolism by soil animals, particularly earthworms.

In the study on the mechanism of action and interaction of pesticides in plants, laboratory results confirmed field observations that the effective narrow-spectrum soil insecticide chlorfenvinphos is a potent plant-growth inhibitor, and the principal site for its action is the membrane of the plant cell. Chlorfenvinphos inhibits water uptake and active transport, yet in high concentrations enhances membrane permeability and permits leakage of cell contents. The effect is dependent on the stage of plant growth and the presence of divalent cations, suggesting interference of other chemicals in the soil with the phytotoxicity of the insecticide.

PLANT DISEASES

Mode of Action of Selected Fungicides

Three systemic fungicides have been investigated carefully this year. Benomyl (and thiabendazole) seed dressings protected pea seedlings from root infection by *Fusarium* spp. However, a detailed analysis of the response of *F. solani* to benomyl in vitro showed that this species readily adapts to high concentrations of the fungicide.

Problems of resistance have also been investigated with carboxin, which failed to control smut in corn seedlings inoculated with compatible resistant mutants of *Ustilago maydis*. Succinate oxidation was inhibited

less by carboxin in resistant than in wild-type strains, thus confirming our previous findings that this is the biochemical site of carboxin action. A more accurate location of this site was found in related studies. In further work, some 30 related carboxamides were synthesized and screened for activity with the use of the succinic dehydrogenase complex as the target site. Active compounds were assayed against a range of pathogenic fungi. Some valuable structure-activity relationships emerged, and several high-activity compounds whose fungicidal spectra differ from carboxin show promise.

The effectiveness of chloroneb in controlling *Pythium ultimum*, damping-off of peas, was synergistically enhanced by thiram or captan. Chloroneb was rapidly taken up by the roots and transported to the leaves, either unaltered or after demethylation and conjugation to a glucoside, in which form it was nontoxic. None of these processes was influenced by thiram. Metabolic products in the fungus were also determined and, although they were glycosidic, they differed from those in the plant in their sugar moiety.

Mechanism of Disease Development and Resistance

Investigations of naturally occurring compounds with potential fungicidal activity have continued with the use of the pepper system for studies on phytoalexins. The study has been broadened to include other Solanaceae (*Solanum melongena*), other host-parasite combinations (such as sunflower-*Verticillium* and rape-*Albugo*), and synthesis of phytoalexins and derivatives for testing as potential fungicides. Thus the production of capsidiol by peppers in response to a variety of fungi is a natural defence mechanism. The compound was also produced in the field. Chemically related compounds have been isolated from *S. melongena*, and the structures of three of these have been determined; one is a new compound and another was isolated from nature for the first time. These findings confirm the theory that phytoalexins in the Solanaceae are characteristically sesquiterpenes and suggest that their production should have a common basis susceptible to genetic manipulation. The stereochemistry of capsidiol has been established by ¹³C-NMR and X-ray analysis and may have significance for the activity of this compound. Capsidiol and some of 19 related compounds

have been screened for fungicidal activity against a range of fungi. Some control of *Phytophthora infestans* on tomatoes and *Erysiphe cichoracearum* on cucumbers has been achieved, and significant structure-activity relationships demonstrated. A synthesis has been developed for the phytoalexin orcinol, which could be adapted for commercial purposes. Some 40 related compounds have also been synthesized and are undergoing fungicidal assessment.

WEEDS

Herbicides and Plant Growth Regulators

Previous work showed that the promotion or inhibition of plant growth by 2,4-D and other plant growth regulators was associated with the level of specific isoenzymes of indoleacetic acid (IAA) oxidase and peroxidase. In an attempt to understand the functional role of these isoenzymes, further work was directed to determine the location and characteristics of the isoenzymes at the subcellular level. The hormone-sensitive IAA oxidase and peroxidase were found not only in the cytoplasm but also associated with plasma membranes. The membrane-bound IAA oxidase has different characteristics, suggesting a possible different role. A high concentration of 2,4-D inhibited the formation of this group of isoenzymes. These findings may be an important step toward understanding the mode of action of auxin herbicides.

Experiments carried out in 1973 confirmed previous findings that the increase in the transpiration of the tomato plants was proportional to the amount of urea or potassium nitrate applied to the soil of the potted plant.

In the study of herbicide-soil microorganism interaction, recommended concentrations of each of paraquat, linuron, diuron, atrazine, and simazine produced no ill effects on growth in cultures of representative strains from each of the seven cross-inoculation groups of rhizobia nor on the proliferation of several rhizobiophages. Similar results were obtained with terbacil even at extremely high concentrations up to 500 μ g/ml. Vorlex (Nor-Am Agricultural Products Ltd.) in the Vorlex-linuron combination was shown to be responsible for reducing drastically the mold population in muck soil under laboratory conditions, whereas low concentrations of linuron favored the recovery.

ENVIRONMENTAL QUALITY

Management of Pesticides

Programs have been established to determine the extent to which insecticide residues are present in soils, plants, and agricultural watersheds as a result of agricultural use of insecticides; and to develop more efficient methods of pesticide management for more effective pest control with a minimum of environmental contamination. Watershed studies were continued or initiated in three locations in southwestern Ontario where insecticides are used extensively: a vegetable muck district, a tobacco area, and an orchard-vineyard watershed. The main insecticide residues found in samples of soil, water, bottom mud, and fish were DDT and its metabolites, and dieldrin. Residues of a number of organophosphorus insecticides were detected in soil in the vegetable muck area. Residues of some organophosphorus insecticides were also detected in drainage canals surrounding the muck area. Low levels of organochlorine insecticides were detected in fish collected from Lake Simcoe adjacent to the muck area, but no residues of organophosphorus insecticides were present. Studies indicated that about 60% of the DDT in water is adsorbed to suspended sediment, but only 10% of the dieldrin and none of the diazinon.

Two programs for developing more effective methods of pesticide management are under way. Good progress is being made in the development of an effective technique for monitoring the annual appearance of the European corn borer. Predictions on the size of population and the time of occurrence in 1973 based on a model developed over the previous 2 yr were very accurate, in spite of unusual weather during 1973. Assuming the monitoring technique works well when utilized by extension specialists, or growers, or both, it should be possible to achieve more effective control of the corn borer with the use of less insecticide. The joint program in cooperation with the University of Guelph for determining the feasibility of controlling the onion maggot by the sterile-male technique was continued, and a limited field study indicated that the release of sterile adults significantly reduced fertility of eggs. Good progress was made in the development of a mass-rearing technique utilizing onions as a source of food.

PUBLICATIONS

Research

- Bond, E. J. 1973. Short communication: Increased tolerance to ethylene dibromide in a field population of *Tribolium castaneum* (Herbst). J. Stored Prod. Res. 9:61-63.
- Bond, E. J., Herne, D. H. C., and Dumas, T. 1973. Control of overwintering stages of mites on apples using ethylene dibromide. Can. Entomol. 105:903-908.
- Bond, E. J., and Uptis, E. 1973. Response of three insects to sublethal doses of phosphine. J. Stored Prod. Res. 8:307-313.
- Bowman, B. T. 1973. The effect of saturating cations on the adsorption of Dasanit, *O,O*-diethyl *O*-[*p*-(methyl sulfinyl)phenyl] phosphorothioate, by Montmorillonite suspensions. Soil Sci. Soc. Am. Proc. 37:200-207.
- Buckland, C. T., and Bond, E. J. 1973. Method of applying methyl bromide to small fumigation chambers. J. Econ. Entomol. 66:992-993.
- Dumas, T. 1973. Inorganic and organic bromide residues in foodstuffs fumigated with methyl bromide and ethylene dibromide at low temperatures. J. Agric. & Food Chem. 21:433-436.
- Gordon, M., Stoessl, A., and Stothers, J. B. 1973. Post-infectious inhibitors from plants. IV. The structure of capsidiol, an antifungal sesquiterpene from sweet peppers. Can. J. Chem. 51:748-752.
- Harris, C. R. 1973. Laboratory evaluation of candidate materials as potential soil insecticides. IV. J. Econ. Entomol. 66:216-221.
- Harris, C. R. 1973. Behaviour and persistence of biological activity of HCS-3260 (AG-Chlordane) in soil under laboratory conditions. Proc. Entomol. Soc. Ont. 103:10-16.
- Harris, C. R., and Svec, H. J. 1973. Toxicological studies on cutworms. XI. Laboratory and field microplot studies on the effectiveness of some experimental insecticides in controlling the redbanded cutworm in organic soil. J. Econ. Entomol. 66:444-446.
- Harris, C. R., Svec, H. J., and Sans, W. W. 1973. Toxicological studies on cutworms. IX. Laboratory and microplot field studies on effectiveness and persistence of some experimental insecticides used for control of the dark-sided cutworm. J. Econ. Entomol. 66:199-203.
- Harris, C. R., Svec, H. J., and Sans, W. W. 1973. Toxicological studies on cutworms. X. Laboratory and field microplot studies on effectiveness and persistence of some experimental insecticides used to control the black cutworm in organic soil. J. Econ. Entomol. 66:203-208.
- Lee, L. M. Y., Krupka, R. M., and Cook, R. A. 1973. Cooperativity in human erythrocyte phosphofructokinase. Biochemistry 12:3503-3507.
- Lee, T. T. 1973. On extraction and quantitation of plant isoperoxidases. Physiol. Plant. 29:198-209.
- Lee, T. T., and Wilkinson, C. E. 1973. Differential response of plant cell membrane to some vinyl organophosphorus insecticides. Pestic. Biochem. Physiol. 3:341-350.
- Marks, C. R., Elliot, J. M., and Tu, C. M. 1972. Effects of deep fumigation on *Pratylenchus penetrans*, flue-cured tobacco, and soil nitrate content. Can. J. Plant Sci. 52:425-430.
- McLeod, D. G. R. 1973. Inheritance of tan head color in the European corn borer, *Ostrinia nubilalis*. Ann. Entomol. Soc. Am. 66:1364-1365.
- Miles, J. R. W., and Harris, C. R. 1973. Pesticides in water. Organochlorine insecticide residues in streams draining agricultural, urban-agricultural, and resort areas of Ontario, Canada—1971. Pestic. Monit. J. 6:363-368.
- Miller, D. M. 1973. The reciprocating flow hypothesis of translocation in plants. Can. J. Bot. 51:1623-1628.
- Nagai, T. 1973. Insect visceral muscle. Excitation and conduction in the proctodeal muscles. J. Insect Physiol. 19:1753-1764.
- Richardson, L. T. 1973. Synergism between chloroneb and thiram applied to peas to control seed rot and damping-off by *Pythium ultimum*. Plant Dis. Rep. 57:3-6.
- Richardson, L. T. Adaptive tolerance of *Fusarium solani* to benzimidazole derivatives *in vitro*. Can. J. Bot. 51:1725-1732.
- Smith, R. C., Starratt, A. N., and Bodnaryk, R. P. 1973. Oviposition responses of *Coleomegilla maculata lengi* (Coleoptera: Coccinellidae) to the wood and extracts of *Juniperus virginiana* and to various chemicals. Ann. Entomol. Soc. Am. 66:452-456.
- Starratt, A. N. 1973. Euphorbiaceae. Cycloartenol and lupeol from *Euphorbia esula*. Phytochemistry 12:231-232.
- Starratt, A. N., and Osgood, C. E. 1973. 1,3-Diglycerides from eggs of *Culex pipiens quinquefasciatus* and *Culex pipiens pipiens*. Comp. Biochem. Physiol. 46B:857-859.

- Stenersen, J., Gilman, A., and Vardanis, A. 1973. Carbofuran: its toxicity to and metabolism by earthworm (*Lumbricus terrestris*). J. Agric. & Food Chem. 21:166-171.
- Stoessl, A., Unwin, C. H., and Ward, E. W. B. 1973. Postinfectious inhibitors from plants. Fungal oxidation of capsidiol in pepper fruit. Phytopathology 63:1225-1231.
- Thompson, A. R. 1973. Persistence of biological activity of seven insecticides in soil assayed with *Folsomia candida*. J. Econ. Entomol. 66:855-857.
- Thorn, G. D. 1973. Uptake and metabolism of chloroneb by *Phaseolus vulgaris*. Pestic. Biochem. & Physiol. 3:137-140.
- Tomlin, A. D., and Forgash, A. J. 1973. Metabolism of gardona by gypsy moth larvae. J. Econ. Entomol. 66:6-9.
- Tu, C. M. 1973. The temperature-dependent effect of residual nematicides on the activities of soil microorganisms. Can. J. Microbiol. 19:855-859.
- Tu, C. M. 1973. Comparison of silica gel plating and most probable number methods for counting nitrifiers in soils. Commun. Soil Sci. Plant Anal. 4:279-283.
- Tu, C. M. 1973. Effects of Mocap, N-Serve, Telone, and Vorlex at two temperatures on populations and activities of microorganisms in soil. Can. J. Plant Sci. 53:401-405.
- Upitis, E., Monro, H. A. U., and Bond, E. J. 1973. Some aspects of inheritance of tolerance to methyl bromide by *Sitophilus granarius* (L.). J. Stored Prod. Res. 9:13-17.
- Vardanis, A. 1973. On the control of glycogen synthetase in mammalian liver. Ann. N. Y. Acad. Sci. 210:215-221.
- Ward, E. W. B., Unwin, C. H., and Stoessl, A. 1973. Postinfectious inhibitors in plants. VI. Capsidiol production in pepper fruit infected with bacteria. Phytopathology 63:1537-1538.

Miscellaneous

- Bond, E. J. 1973. The toxic action of fumigants on insects. Pages 1-20 in S. K. Majumder and J. S. Venugopal, eds. Fumigation and gaseous pasteurization. Academy of Pest Control Sciences, Manipal Power Press, Mysore, India.
- Bond, E. J. 1973. Chemical control of stored grain insects and mites. In R. N. Sinha and W. E. Muir, eds. Grain storage: part of a system. Avi Publishing Co., Westport, Conn.
- Harris, C. R., Thompson, A. R., and Tu, C. M. 1972. Insecticides and the soil environment. Proc. Entomol. Soc. Ont. 102:156-158.

Engineering Research Service Ottawa, Ontario

PROFESSIONAL STAFF

C. G. E. DOWNING, B.E., M.Sc., F.A.S.A.E., F.E.I.C., F.C.S.A.E.	Director
K. B. MITCHELL	Administration

Development and Advisory Section

J. E. TURNBULL, B.S.A., M.S.A.	Head of Section; Livestock structures
M. FELDMAN, B.E., M.Sc.	Field mechanization
F. R. HORE, B.S.A., M.S.	Water resources
J. H. HUTT, B.Sc. (Eng.), M.Sc.	Systems analysis
H. A. JACKSON, B.Sc. (Eng.), M.Sc.	Storage structures
K. W. LIEVERS, B.Sc. (Agr.), M.Sc.	Systems analysis
P. A. PHILLIPS, B.Sc. (Agr.), M.Sc.	Waste management

Research Service Section

P. W. VOISEY, M.I., Mech.E.	Head of Section; Instrumentation
E. J. BRACH, D.E.E., Dip.Mil.Electronics	Electronics
D. J. BUCKLEY, B.E., M.Sc.	Electronics
W. S. REID, B.Sc. (Agr.), M.Sc.	Mechanical
G. E. TIMBERS, B.S.A., M.S.A., Ph.D.	Food process engineering

Technical and Scientific Information Section

G. F. MONTGOMERY, B.Sc. (Agr.)	Head of Section
--------------------------------	-----------------

Departure

D. J. COOPER, B.Sc. (Agr.) Retired January 1973	Head of Technical and Scientific Information Section
--	---

INTRODUCTION

A new program in agricultural engineering mechanization was started to follow the new government policy of "make or buy" for additional research and development programs. Initially the program includes three contracts on high-priority projects: one at the University of Saskatchewan on mechanized-equipment improvement to control wild oats and to clean them from the harvested crop; a second at the Nova Scotia Agricultural College on the recycling of animal waste to produce organic protein for ruminant animals and for use as improved fertilizer; and a third at the University of Manitoba to determine the technique and economic feasibility of methane gas production for energy purposes through anaerobic digestion of animal waste. The program proposes to support the fundamental research and development activities at universities, research institutes, and industry and the applied development and equipment evaluation at provincial agencies, industry, or other commercial agencies. This program will speed up the development of special machines and equipment for agricultural production in Canada and the field-performance evaluation of new machines to facilitate farm-management decisions.

Technical consultation was increased with Branch establishments, other government agencies, universities, and industry. Participation in seminars and short courses for provincial extension engineers, farm organizations, and industrial groups and in special research-planning committees was expanded.

The Canada Farm Building Plan Service developed more quick-design leaflets and special publications. ERDA continued to effectively communicate new technology to a wide readership nationally and internationally.

Mr. D. J. Cooper, who worked on farm drainage and soil and water developments and was responsible for the development of the publication ERDA, retired after 27 yr of service.

For more information, address correspondence to: Director, Engineering Research Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

C. G. E. Downing
Director

DEVELOPMENT AND ADVISORY

Developmental Research

Forage-systems evaluation was continued at the Research Station, Melfort, Sask. The hay tower was modified and filled for the third time; some operational difficulties are still to be solved. Measurements of field drying rate for 4 yr indicate that conditioned, swathed hay is about 5% dryer after a curing period than hay made by other treatments. Unless windrows are extremely heavy, conditioned hay in the windrow may be ready for packaging just as quickly as hay in the swath, because swaths that dry more quickly are also rewetted more quickly by dew or rain. Big-package systems (stacks, giant bales) are being compared with silage and regular bale systems. Data on hay-drying rates, handling methods, and hay and silage storage losses are being added to a simulation and analysis study of forage systems.

Simulation and analysis of western grain-harvesting and handling systems were continued. A grain-harvesting simulation program from England was tried, but it is not yet operational on the Agriculture Canada computer facilities.

After a field survey of rape swathing problems in Western Canada, recommendations for various swather modifications were made to swather manufacturers. Suggestions were made to develop rape varieties and cultural practices aimed at the reduction of lodging and excessive vegetative growth.

In cooperation with the Animal Research Institute, corn silage densities and storage losses were again measured in a 9 × 24-m (30 × 80-ft) concrete tower silo. Storage losses from the 1972 crop, which was ensiled at 68% moisture, were 11% of the total contents and 7.1% of the dry matter. The 1973 crop was stored at 58% moisture.

To extend the time available for field spreading, liquid manure was injected between rows of growing corn with no

apparent damage to corn up to 0.6 m (2 ft) in height at the Greenbelt Farm of the Animal Research Institute (A.R.I.). A three-row injector applied liquid at 22–90 t/ha (10–40 tons/ac); at 25- to 30-cm (10- to 12-in.) penetration the three-row injector required on the drawbar an average of 60 hp and peaks to 90 hp. Crop response with liquid manure and no spring fertilizer was compared with the regular fertilizer program; the results are pending.

The *Canada Animal Waste Management Guide* was prepared and issued by a federal-provincial committee, to consolidate the best available information applicable to Canadian conditions. Information gaps revealed by the preparation of this guide have resulted in the starting of a systems analysis project in animal waste management (beginning with dairy cattle systems) and a manure-storage runoff monitoring program across Ontario. Measurement of field-runoff rates and pollution potential was begun at instrumented sites on the A.R.I. Greenbelt Farm and the Central Experimental Farm.

Porous ceiling ventilation gave satisfactory winter humidity and odor control in a free-stall dairy barn at Normandin, Que.; further modifications are being tried to produce more uniform barn temperature.

Canada Farm Building Plan Service (CFBPS)

The CFBPS Design Center, in cooperation with provincial subcommittees and the Information Division, prepared and distributed 31 plan sets (85 drawing sheets) and 22 catalog leaflets. These were mainly plans for dairy housing, fruit and vegetable storages, and special structures. Dairy plans included three new manure storages designed for pollution control relating to the *Canada Animal Waste Management Guide*.

Several 3-day training courses in drafting and illustrating procedures were presented to provincial draftsmen from Quebec (2 men), the Maritime Provinces (9), and the Western Provinces (10).

Quick-design leaflets were developed for choosing structural components for farm buildings including roof trusses, roof purlins, wall posts and columns, wall plate beams, and insulation requirements for fruit and vegetable storages. These and other structural concepts, such as the design of silo walls

and footings, were presented in seminars to the Ontario extension engineers.

RESEARCH SERVICE

Equipment for Mechanization of Field and Laboratory Experiments

Two fertilizer dispensers were developed for use on experimental plots. A new forage-plot seeder was developed, and the Swift Current seeder was modified to expand its performance. A commercial system for protecting test plots by netting was investigated.

An automatic system for collecting 1 to 24 water samples at preselected times was developed for field-drainage experiments. A plant coldhardiness cabinet was developed in which the temperature cycle required was programmed by plotting a curve to control temperatures from 0 to -24°C within $\pm 0.5^{\circ}\text{C}$.

An automatic door to allow individual beef animals access to their assigned feed was evaluated and found to operate under Canadian winter conditions. An improved surgical table system was developed to handle animals ranging from sheep to cattle to provide the veterinarian with fingertip control to position the animal.

Mechanization Applied to Field Crops

A forage harvester was modified to harvest whole tobacco plants, in order to investigate a new harvesting method and to study new curing techniques for this crop.

A process was developed for drying sugar cane pith and forming it into wafers to make a storable animal feed in the West Indies.

The production of fababeans for canning or freezing was investigated. Commercial seeders were satisfactory, and modified pea-harvesting equipment harvested the crop efficiently.

Commercial harvesters appeared to be satisfactory for the harvesting of minicarrots on muck soils. Planting experimentation for higher yields is required.

Instrumentation

Several data acquisition systems were designed for different applications. The infrared spectral reflectance characteristics of chicken feathers and skin were established to provide poultry housing design parameters.

It was found that infrared reflectance of conifers did not provide an indication of the plant's biological activity (dormancy and winterhardiness). Instruments were developed to record field evaporation and solar energy in meteorological measurements.

A technique based on level controls and a timing mechanism was developed to record the rate of flow from cows during milking.

A borescope and camera attachment were assembled to record the development of plant roots.

Processing and Quality Measurement

The thermal properties of rapeseed were established. An extruder was instrumented to study starch gelatinization in cereal processing. Reverse osmosis was successfully applied to the concentration of cranberry juice and second-press apple juice. The procedure has commercial applications.

Instruments and techniques were developed for measuring the quality of various foods such as the firmness of licorice candy, French fry limpness, and onion firmness. New apparatus was developed for determining the quality of wheat flour by measuring

dough-mixing and water-imbibing properties.

It was found that the effect of storage time on canned baked beans was to increase the variability of their texture.

TECHNICAL AND SCIENTIFIC INFORMATION

The section has established a broad-based information retrieval system. It includes most of the recent papers from Canadian and American agricultural engineering societies, journal articles, and documents from many other sources. It has been used to prepare special bibliographies on systems engineering and agricultural pollution.

Many reports, journal articles, and other documents have been added to the section's collection of agricultural engineering information.

Items of current interest were disseminated to individuals involved with agricultural engineering by means of the periodical ERDA. A list of agricultural engineering research and development projects was prepared and published as a supplement to ERDA.

PUBLICATIONS

Research

Brach, E. J., and Mack, A. R. 1973. Instrumentation development for characterization of crops by spectrophotometry. *Trans. Instrum. Soc. Am.* 12:217-226.

Brach, E. J., Reid, W. S., and St. Amour, G. P. 1973. Optical reflectance attachment to measure reflectance properties of grain products. *J. Phys. E, Sci. Instrum.* 6:634-636.

Brach, E. J., Wilner, J., and St. Amour, G. P. 1973. Data acquisition of winterhardiness and temperature from living plants via telemetry. *Med. & Biol. Eng.* 11:164-175.

Buckley, D. J., Reid, W. S., and Voldeng, H. D. 1973. A digital leaf area measuring system using a television-scanned conveyor. *J. Can. Soc. Agric. Eng.* 15:107-109.

Hergert, G. B. 1973. A corn sheller for experimental samples. *Can. J. Plant Sci.* 53:647-648.

Hergert, G. B. 1973. A laboratory classifier for separation of ground products by terminal velocity. *Can. Inst. Food Sci. & Technol. J.* 6:298-299.

Hergert, G. B. 1973. A laboratory oat polisher. *Can. J. Plant Sci.* 53:649-650.

Hergert, G. B., and Gall, J. 1973. Modification to an automatic liquid sampler to take multiple samples. *Can. J. Soil Sci.* 53:483-484.

Kalab, M., Voisey, P. W., Harwalker, V. R., and Larose, J. A. G. 1973. Heat-induced milk gels. VI. Effect of temperature on firmness in comparison with some common gels. *J. Dairy Sci.* 56:998-1003.

Khan, A. W., and Voisey, P. W. 1973. Determination of shear force value of major beef muscles. *Can. Inst. Food Sci. & Technol. J.* 6:47-49.

Larmond, E., and Voisey, P. W. 1973. Evaluation of spaghetti quality by a laboratory panel. *Can. Inst. Food Sci. & Technol. J.* 6:209-211.

- Lasztity, R., and Voisey, P. W. 1973. Hungarian quality control instruments. Their applications in industry, agriculture and scientific research. *Can. Inst. Food Sci. & Technol. J.* 6:22-28.
- Reid, W. S. 1973. A polycarbonate plastic bed for a fluidized bed freezer and dryer. *Can. Inst. Food Sci. & Technol. J.* 6:148-150.
- Tanaka, M., deMan, J. M., and Voisey, P. W. 1973. Some rheological properties of whipped toppings. *Chem. Mikrobiol. & Technol. Lebensmittel.* 2:1-6.
- Timbers, G. E. 1973. Food engineering in Agriculture Canada. A review. *J. Can. Soc. Agric. Eng.* 15:93-98.
- Timbers, G. E. 1973. Measurement of moisture in foods. *Proc. 2nd Annu. Instrum. Soc. Am. Food Beverage Instrum. Symp., Montreal.* pp. 45-49.
- Voisey, P. W., and Crête, R. 1973. A technique for establishing instrumental conditions for measuring food firmness to simulate consumer evaluations. *J. Texture Stud.* 4:371-377.
- Voisey, P. W., and Larmond, E. 1973. An exploratory evaluation of instrumental techniques for measuring some textural properties of cooked spaghetti. *Cereal Sci. Today* 18:126-133, 142-143.
- Voisey, P. W., and Nonnecke, I. L. 1973. Measurement of pea tenderness. 5. The Ottawa pea tenderometer and its performance in relation to the pea tenderometer and F.T.C. texture test system. *J. Texture Stud.* 4:323-343.
- Voisey, P. W., and Nonnecke, I. L. 1973. Measurement of pea tenderness. 2. A review of methods. *J. Texture Stud.* 4:171-195.
- Miscellaneous**
- Brach, E. J., Montour, M., and St. Amour, G. P. 1973. Cancellation of spectrophotometer system characteristics using an analog computer. *Lab. Pract.* 22:631-632.
- Buckley, D. J. 1973. Preliminary evaluation of the Valeriotte individual animal feeding gate system. *Rep. 6707. Eng. Res. Serv.* 9 pp.
- Downing, C. G. E. 1973. Goals of agricultural research in Canada. Paper NC73-102. *Annu. Conf. North Cent. Reg. Am. Soc. Agric. Eng., Regina.* 8 pp.
- Engineering Research Service. 1973. Current agricultural engineering research and development projects in Canada 1973. *ERDA Suppl.* 6. 29 pp.
- Feldman, M. 1973. Investigation of rapeseed swathing problems in Saskatchewan. Paper 73-312. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 11 pp.
- Feldman, M. 1973. Reciprocating power harrows. *Canadex* 741.
- Feldman, M. 1973. Save energy—save dollars. *Canadex* 717.
- Feldman, M., and Beacom, S. E. 1973. Effect of harvesting equipment and bale management methods on hay quantity and quality. Paper 73-310. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 21 pp.
- Feldman, M., and Friesen, O. H. 1973. Performance of reciprocating power harrows in some Canadian conditions. Paper 73-328. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 21 pp.
- Feldman, M., and Hore, F. R. 1973. Current developments in equipment for injecting liquid manure into the soil. Paper 73-303. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 13 pp.
- Feldman, M., and Lievers, K. W. 1973. Effect of cutting method and conditioning on field drying rates of hay in Saskatchewan. Paper 73-308. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 22 pp.
- Hergert, G. B. 1973. Bulk seeder for experimental planting. *Rep. 7233. Eng. Res. Serv.* 10 pp.
- Hergert, G. B. 1973. Flail clutch and roller height adjuster for Swift Current forage harvesters. *Rep. 7215. Eng. Res. Serv.* 4 pp.
- Hergert, G. B. 1973. Recommendations for testing mechanical aspects of growing broad beans for processing in Quebec. *Rep. 7302-2. Eng. Res. Serv.* 12 pp.
- Hore, F. R. 1973. Animal waste management research in Canada. *Annu. Pac. Northwest Reg. Am. Soc. Agric. Eng., Calgary.* 11 pp.
- Jackson, H. A. 1973. Packed vs unpacked silage. *Canadex* 120.52.
- Jackson, H. A., Feldman, M., and Beacom, S. E. 1973. Progress in development of a hay tower for drying, storing and mechanically handling chopped hay. Paper 73-501. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 8 pp.
- Jackson, H. A., and Robertson, J. A. 1973. Comparison of packed and nonpacked storage of silage in horizontal silos in a cold climate. Paper 73-215. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 6 pp.
- Phillips, P. A., and Ogilvie, J. R. 1973. Modelling short-term minimum aerobic treatment of swine manure. Paper 73-221. *Annu. Conf. Can. Soc. Agric. Eng., Victoria.* 16 pp.
- Reid, W. S. 1973. Processing options to produce sheet tobacco with cost estimates for two pilot plant processes. *Rep. 7310. Eng. Res. Serv.* 36 pp.

- Reid, W. S., and Timbers, G. E. 1973. Physical properties of five varieties of apples associated with potential improvements in processing machinery. Paper 73-321. Annu. Conf. Can. Soc. Agric. Eng., Victoria. 29 pp.
- Timbers, G. E. 1973. Concentration and recovery of second press apple juice. Rep. 7235. Eng. Res. Serv. 11 pp.
- Timbers, G. E. 1973. Thermal diffusivity and specific heat of rapeseed. Rep. 7142-1. Eng. Res. Serv. 23 pp.
- Turnbull, J. E. 1973. Dairy herd replacement heifer housing. Calf Nutr. Manage. Workshop. MacDonald College, Que. 10 pp.
- Turnbull, J. E. 1973. Design of footings for concrete tower silos. Ont. Minist. Agric. & Food Silo Semin., February. 6 pp.
- Turnbull, J. E. 1973. Engineering for intensive housing of livestock. Can. Dep. Agric. Publ. 1503. 26 pp.
- Turnbull, J. E. 1973. Environmental requirements for mature dairy cows. Proc. Am. Soc. Agric. Eng. Natl. Dairy Housing Conf., East Lansing, Mich. pp 142-153.
- Turnbull, J. E. 1973. Planning swine housing facilities. Quinte Pork Prod. Conf., Peterboro, Ont. 9 pp.
- Turnbull, J. E., and Darisse, J. P. F. 1973. Ventilation of dairy barns with porous ceiling inlet systems. II. Paper 73-216. Annu. Conf. Can. Soc. Agric. Eng., Victoria. 12 pp.
- Turnbull, J. E., and Guertin, S. M. 1973. Shear and buckling resistance of cladding materials used as structural diaphragms in farm buildings. Paper 73-213. Annu. Conf. Can. Soc. Agric. Eng., Victoria. 16 pp.
- Turnbull, J. E., and Hickman, C. G. 1973. Ventilation of dairy barns with porous ceiling inlet systems. I. Paper 73-216. Annu. Conf. Can. Soc. Agric. Eng., Victoria. 8 pp.
- Turnbull, J. E., and Hore, F. R. 1973. Current trends in handling livestock wastes. Proc. Work Plann. Meet. on Agric. and Environ. Qual. Res. Branch, Agric. Can., Ottawa. pp. 58-66.
- Voisey, P. W. 1973. An electronic attachment to replace mechanical dynamometers used to record torque in mixers and extruders. Rep. 7228. Eng. Res. Serv. 25 pp.
- Voisey, P. W. 1973. Firmness of candy licorice. Rep. 7319. Eng. Res. Serv. 17 pp.
- Voisey, P. W. 1973. Some measurements of baked bean texture. Rep. 7222. Eng. Res. Serv. 6 pp.
- Voisey, P. W. 1973. The interchangeability of instruments used to measure pea tenderness. Rep. 6820-6. Eng. Res. Serv. 23 pp.
- Voisey, P. W., and Balke, W. G. 1973. Summary of projects and publications. Eng. Specif. 7300. Eng. Res. Serv. 17 pp.
- Voisey, P. W., and Hergert, G. B. 1973. A review of transplanters. Rep. 7321. Eng. Res. Serv. 4 pp.
- Voisey, P. W., and Hunt, J. R. 1973. Apparatus and techniques for measuring eggshell strength and other quality factors. Eng. Specif. 6176. Eng. Res. Serv. 63 pp.
- Voisey, P. W., and Kloek, M. 1973. Measurements relating to pea tenderometer calibration. Rep. 6820-3. Eng. Res. Serv. 26 pp.
- Voisey, P. W., and Larmond, E. 1973. A comparison of the textural properties of several spaghetti varieties and some observations on the accuracy of an objective technique. Rep. 7008-1. Eng. Res. Serv. 57 pp.
- Voisey, P. W., and Nonnecke, I. L. 1973. Some observations regarding pea tenderometer standardization. Rep. 6820-5. Eng. Res. Serv. 21 pp.
- Voisey, P. W., and Nonnecke, I. L. 1973. Summary of results—Pea tenderometer tests. 1968-1973. Rep. 6820-7. Eng. Res. Serv. 13 pp.
- Voisey, P. W., and Timbers, G. E. 1973. Where we stand in instrumentation for food quality measurement. Can. Controls Instrum. 12(3):34-38.
- Voisey, P. W., Buckley, D. J., and Crête, R. 1973. Evaluation of a system for measuring small deformations in the physical testing of foods. Rep. 7221. Eng. Res. Serv. 39 pp.
- Voisey, P. W., Heeney, H. B., and Nonnecke, I. L. 1973. The effect of variety on the relationships between readings from instruments for measuring pea maturity and tenderness. Rep. 6820-4. Eng. Res. Serv. 51 pp.
- The following publications are available in both English and French.
- Hergert, G. B. 1973. A review of equipment for harvesting root crops. Rep. 7302-4. Eng. Res. Serv. 15 pp.
- Hergert, G. B. 1973. Harvesting baby carrots. Rep. 7302-5. Eng. Res. Serv. 5 pp.
- Hergert, G. B. 1973. Report on harvesting investigation using a Tawco radish combine for baby carrots. Rep. 7302-6. Eng. Res. Serv. 6 pp.
- Hergert, G. B., and Jasmin, J. J. 1973. Field equipment for broad beans grown for processing. Rep. 7302-3. Eng. Res. Serv. 6 pp.

Reid, W. S. 1973. Preliminary survey of equipment for harvesting broad beans, carrots, radishes and shallots. Rep. 7302. Eng. Res. Serv. 11 pp.

Ornamentals Research Service

Ottawa, Ontario

PROFESSIONAL STAFF

A. CHAN, B.Sc., M.Sc., Ph.D.

Director

Administration

J. S. ANDERSON

Office Manager

B. W. JABLONSKI, B.L.A.

Landscape Architect

Ornamentals Research

W. E. CORDUKES, B.Sc., M.Sc.

Chief of Section; Turfgrass

A. T. BOLTON, B.Sc., M.Sc., Ph.D.

Pathology of ornamental plants

J. MOLNAR, B.Sc., M.Sc., Ph.D.

Floriculture

E. V. PARUPS, M.S.A., Ph.D.

Physiology of ornamental plants

F. J. SVEJDA (Miss), Ph.D.

Ornamental plant breeding

J. WILNER, B.S.A., M.Sc., Ph.D.

Frost hardiness and nursery
research

Departure

A. R. BUCKLEY

Ornamental horticulture

Retired August 1973

INTRODUCTION

The Ornamentals Research Service was established in 1973 to strengthen research on ornamental plants. The Service is also responsible for the Department's Arboretum and Botanic Garden at Ottawa.

A new balanced program on floriculture is becoming very productive. The addition of a pathologist to the staff has been an important move to meet the needs of the industry.

Turfgrass research has been accelerated and more cooperative work with sod producers and turf management personnel is being developed.

The Test Gardens continued to provide useful appraisals of new ornamental cultivars to the trades and the general public.

Correspondence should be addressed: Director, Ornamentals Research Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6.

Allan Chan
Director

ORNAMENTAL PLANTS

Control of Foliar Nematodes

The introduction of Rieger elatior begonias to Canadian consumers is impeded by the susceptibility of these plants to foliar nematodes.

Plants of the Rieger elatior begonia cultivar Schwabenland Red were infested with foliar nematodes and left undisturbed for 6 wk to increase infestation. The plants were sprayed with the systemic insecticides Vydate (DuPont of Canada Ltd.), Temik 10% granular (G) (Union Carbide Corp.), and DS15647 (Diamond Shamrock Canada Ltd.). Vydate gave the most effective control without damaging the plants. Temik 10G gave fairly good control and caused only minor foliage injury on some plants. DS15647 gave only partial control but did not have any phytotoxic effects.

Tissue Culture

Cyclamen tuber tissues are being cultured to obtain disease-free stock plants. Two kinds of culture media have been used, both in liquid and solid states. However, organ differentiation appears to be very slow. Some root growth and vegetative bud initials have been obtained in some cultures.

Response to Growth Regulators

Auxin and red light are known to control the rate of ethylene synthesis in plants. Exogenously supplied acetylcholine inhibited ethylene synthesis, probably because the

acetylcholine mimicked the effects of red light on phytochrome.

The diatotropic mutant of tomato, *dgt*, requires ethylene for normal, upright growth and has low levels or activities of cystathionase, the enzyme involved in the synthesis of methionine. The relatively low levels of methionine (a precursor of ethylene) thus contributed to a decrease in ethylene, indicating that a certain minimal amount of ethylene synthesis capacity is required for normal plant growth.

The rate of peroxidation of lipids in petals was considerably lower in chrysanthemums than in roses or carnations and may be an important factor in the relative longevity of these flowers.

Evaluation of Woody Plants

The new viburnum cultivars introduced during the last few years by the US National Arboretum have been growing long enough for their hardiness to be judged. Most of them appear to be hardy in this climate, but the varieties Iroquois, Mohawk, and Susquehanna are too tender for this area. New plantings were made of magnolias, rhododendrons and azaleas in a sheltered area of the arboretum to evaluate their winter-hardiness.

Evaluation of Annuals

Annuals selected for intensive testing were *Celosia* (40 cultivars), *Impatiens* (78 cultivars), *Salvia* (70 cultivars), *Lobularia* (10 cultivars), and *Ageratum* (20 cultivars). The *Celosia* varieties can be divided into two

types, the cristata or cockscomb hybrids and the plumosa or feathered hybrids. The cockscomb hybrids were outstanding and more uniform than when last tested; the varieties Empress Re-selected and Empress Rose were the best. Among the feathered hybrids, Fiery Feather, Golden Feather, Crusader, and two mixtures, Fairy Fountains and Meadowglow, rated highest.

New improved types of balsam (*Impatiens*) with bicolored or multicolored flowers, such as Freckles, Peppermint, and Princess Sakura, were introduced. In the ordinary *Impatiens*, new strains such as Elfin, Imp. Melody, Minette, Shadeglow, and Treasure are now more uniform and floriferous and are available in a wide range of individual colors or as mixtures.

Turfgrass Growth in Salt-contaminated Soils

Samples of the cultivated layer of Carp clay loam, Osgoode sandy loam, and Uplands sand were treated with $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ at rates of 0, 2,000, 8,000, 12,000, and 16,000 ppm and cropped in the greenhouse to perennial ryegrass, Kentucky bluegrass, and creeping red fescue. The quality of turf of the three species was not affected by salt contamination at the rate of 2,000 ppm (soil conductivity of 7.2 mmhos/cm in a saturated paste). When the rate was increased to 8,000 ppm (soil conductivity of 20 mmhos/cm), the turf deteriorated markedly in the clay loam and sandy loam and to a lesser degree in the sand. Deterioration of turf quality was accompanied by less root development.

Mercury Content of Golf Course Greens

In 1970 and 1971 turf and soil samples were obtained from several greens and fairways of three local golf courses to establish the mercury (Hg) levels that might be encountered on area courses. Samples were taken from greens and at 8-m (25-ft) intervals out from the greens to a distance of 30 m (100 ft). The Hg level of three surface samples collected at the Central Experimental Farm was 0.05 ppm. The Hg content of the greens averaged 53 ppm and ranged from 27 to 65 ppm. The amounts decreased with distance from the green and dropped abruptly below the 15-cm (6-in.) depth. However, there was also evidence of Hg leaching to a depth of 76 cm (30 in.) and of

lateral movement through tile drains to at least 30 m (100 ft) from the green.

Container-grown Nursery Stock

Bioelectric studies showed that impedance readings of about 85,000 ohms for roots, with a shoot-to-root impedance ratio of about 2.0:1.0, a soil temperature of about 2°C (35°F), and an air temperature of about -4°C (25°F) were optimum conditions for overwintering of container stock.

During the growing season varietal differences were found in the adaptability of nursery plants when transplanted from the field to containers. The slow-release fertilizers Osmocote and I.B.D.U. were as effective as the soluble 20-20-20 fertilizer. Soil temperatures in containers located on the ground surface were about 7°C (12°F) higher than those in the soil, but no visible growth differences were noted. Runner roots protruding through the drainage holes of containers did not contribute to the growth of nursery stock. No apparent differences were noted in the effect of 9- and 14-litre (2- and 3-gal) containers on growth of hybrid tea roses 3 yr of age.

Autumn application of Ethrel (Amchem Products Inc.), but not of Alar (UniRoyal Chemical), induced early maturity of container-grown plants.

In winter the survival of container-grown plants outdoors was comparable with the survival of those stored indoors. Spraying plants stored indoors with antidesiccants such as Foligard, Silvoplast, and Wiltproof did not improve their survival over the control plants.

Soil-borne Diseases of Greenhouse Ornamentals

Pythium splendens Braun was isolated from Rieger begonias at Ottawa. This species caused severe damage to a wide range of plants placed in infested soil. An efficient method of testing the efficacy of soil fungicides was developed in which cucumber seedlings and rooted cuttings of geranium were planted in soil inoculated with *P. splendens*. The soil was then drenched with the particular fungicide. Good control was obtained with several of the fungicides tested.

Shade Tree Diseases

Verticillium dahliae Kleb. was isolated from several maple and elm trees in eastern Ontario. The fungus caused necrosis and death of several branches of large trees. Partial recovery was observed in several large maple trees after a heavy application of high-nitrogen fertilizer.

Foliage Color of Seedlings of *Prunus virginiana* 'Shubert'

The cultivar Shubert has purple foliage. It is very hardy and may be clipped into a hedge, but the new shoots have green leaves. The development of foliage color was examined during the first growing season on

seedlings from open pollination to determine whether it would be feasible to obtain plants with purple foliage only. Color ratings were carried out in March, July, and September as follows: green, if there was no other color; variable, if more than 75% of the foliage was green; and purple, if green was less than 25%. The rating in March yielded 61% green, 20% variable, and 19% purple seedlings. When the green seedlings were rated later, 50 seedlings were still green, but 11 had turned purple. Generally, the purple seedlings retained the color throughout the season but two turned green. These data showed that seedlings with predominantly purple foliage can be obtained and that very young seedlings can be selected for foliage color.

PUBLICATIONS

Research

- Brach, E. J., Wilner, J., and St. Amour, G. 1973. Data acquisition of winterhardiness and temperature from living plants via telemetry. *Med. & Biol. Eng.* 11:164-175.
- Cordukes, W. E., and MacLean, A. J. 1973. Tolerance of some turfgrass species to different concentrations of salt in soils. *Can. J. Plant Sci.* 53:69-73.
- MacLean, A. J., Stone, B., and Cordukes, W. E. 1973. Amounts of mercury in soil of some golf course sites. *Can. J. Soil Sci.* 53:130-132.
- Parups, E. V. 1973. Control of ethylene-induced responses in plants by a substituted benzothiadiazole. *Physiol. Plant.* 29:365-370.
- Parups, E. V., and Chan, A. P. 1973. Extension of vase-life of cut flowers by use of isoascorbate-containing preservative solutions. *J. Am. Soc. Hortic. Sci.* 98:22-26.
- Parups, E. V., and Peterson, E. A. 1973. Inhibition of ethylene production in plant tissues by 8-hydroxyquinoline. *Can. J. Plant Sci.* 53:351-353.
- Svejda, F. 1972. New hybrids of roses. *Proc. 18th Int. Hortic. Congr. Tel Aviv, 1970(1):225, Abstr.* 456.

Miscellaneous

- Buckley, A. R. 1973. Order bulbs now to popularize your department next spring. *Recreation Can.* 31(4):23 and 27.
- Buckley, A. R. 1973. The herb garden. *Ottawa Hortic. Soc. 1973 Yearbook.* pp. 20-21.
- Buckley, A. R. 1973. Trees that weep. *Horticulture* 51(1):52-53.
- Cavaye, W. M., and Buckley, A. R. 1972. Recommended list of annual plant varieties. *Greenhouse-Garden-Grass* 11:53-57 and 81-86.
- Chan, A. P. 1973. Controlled plant environments. *Canadex* 731.
- Molnar, J. M. 1973. Practical grower research in Ottawa. *Can. Florist* 68(9):22-28.
- Parups, E. V. 1972. 'Ekatin' for disbudding of chrysanthemums. *Greenhouse-Garden-Grass* 11:75-79.
- Parups, E. V. 1973. Chemical modification of ethylene responses in plants. *Symp. Postharvest Physiol. of Cut Flowers.* Littlehampton, U.K.
- Parups, E. V. 1973. Preharvest and postharvest physiology of roses. *Roses Inc. Bull. Feb.* pp. 15-18.
- Wilner, J. 1973. Electrical methods of measuring and reporting cold hardiness of plants. *Greenhouse-Garden-Grass* 12:11-14.

Statistical Research Service

Ottawa, Ontario

PROFESSIONAL STAFF

L. P. LEFKOVITCH, B.Sc.
C. S. SHIH, B.Sc., M.Sc., Ph.D.

Director
Head of Biometrics Section;
Design of experiments, crop-loss studies

M. R. BINNS, M.A., Dip. Stat.
D. R. CAMERON,¹ B.Sc., M.Sc., Ph.D.
D. J. CLARK,² B.S.A.
L. M. A. GRAHAM (Ms.),² B.A.
H. N. HAYHOE,³ B.Sc., M.Sc., Ph.D.
J. HUTT,⁴ B.Sc., M.Sc.
K. W. LIEVERS,⁴ B.Sc., M.Sc.
C. S. LIN, B.Sc., M.S., Ph.D.
P. M. MORSE (Ms.), M.A.
D. L. PAULHUS,² B.Sc.
D. R. PERRON,²
K. R. PRICE, B.Sc., M.Math.

Design of experiments, sampling
Soils systems models
Senior programmer
Systems and programming
Agrometeorological models
Animal housing models
Harvesting models
Quantitative genetics
Bioassay, design of experiments
Systems and programming
Systems and programming
Design and analysis of
experiments, systems analysis
Systems and programming
Quality control
Time series, multivariate analysis
Quantitative genetics, design and
analysis
Genetics, design and analysis
Systems and programming
Design and analysis

G. P. POUSHINSKY,² B.Sc.
S. PURI,⁵ B.A., M.A., M.Sc.
B. REISER, B.Sc., M.Math., Ph.D.
D. T. SPURR, B.Sc., M.Sc., Ph.D.

B. K. THOMPSON, B.Sc., M.Math.
J. TSANG (Ms.),² B.Sc.
C. J. WILLIAMS, B.S.A., M.Sc., Ph.D.

Departure

B. J. HACHE, B.Sc.
Transferred to Environment Canada, September
1973

Systems and programming

¹Soil Research Institute, Systems Group.

²Finance and Administration Branch, Data Processing Division.

³Chemistry and Biology Research Institute, Systems Group.

⁴Engineering Research Service, Systems Group.

⁵Production and Marketing Branch Statistician.

INTRODUCTION

In 1973, the Statistical Research Service provided advice and assistance on some 170 problems on design, analysis, and interpretation of experimental data, and also on some nonstatistical mathematics.

Cooperation with other scientists in the Research Branch has been close, especially in assessment of crop losses, in bioassay, in numerical taxonomy, and in applied ecology. A new development has been the formation of a scientific modeling group for agriculture; the group consists of scientists from three other institutes as well as this Service.

The library of computer programs has had to be modified because of changes in the operating system of the Univac 1108 machine normally used; every subprogram has had to be verified and the differences understood or errors rectified. New programs placed in the library include ones to perform time-series analysis, both in autoregressive and spectral contexts; canonical and discriminant analysis by the Q-technique, for trend-surface analysis; eight further methods of cluster analysis; an information-theoretic method for the evaluation of attributes; and a method for path coefficients. New mathematical procedures include some further methods of function optimization, and eigenvalue procedures improved in both accuracy and speed, for singular value decomposition, and for the exact distribution of Wilks' criterion.

For more information, correspondence should be addressed to: Director, Statistical Research Service, Research Branch, Agriculture Canada, Room E266, Sir John Carling Building, Ottawa, Ont. K1A 0C5.

L. P. Lefkovitch
Director

Plant Science

A procedural approach for analyzing the data of cooperative varietal trials was developed. By a combination of the techniques of cluster and regression analysis, the test varieties are grouped so that those within each group have a common regression on environmental indexes. The method gives a picture of the general response pattern and provides an objective way to select varieties for a specific range of environments.

In further study of compact designs for spacing experiments, it was found that possible heteroscedasticity owing to unequal plot size can be examined by analyzing the data separately for each level of row or column spacing. Analysis of a corn experiment that used the compact design showed that the spacing arrangement of the plants affected the yields of treatments with identical plant density. Regardless of the experimental design, a general problem with spacing experiments is the poor fit obtained for response surfaces. A partial remedy is to make a more critical choice of treatment levels and to increase the number of replications.

Regression analysis has been used to study a variety of other problems. One of these concerned the spacing of irrigation sprinklers

to give a uniform distribution of water over a tobacco field. In another study, regression lines were fitted to relate legume yield to soil pH under two regimes. Among other problems investigated were the grain yield of spring wheat in relation to the rate and duration of grain filling; the effect of weather on the yields of brome grass varieties; and the relationship between yield of flax and various yield components and agronomic characteristics.

Investigations were carried out to estimate the combining ability of lowbush blueberry varieties, and to assess the performance of reed canarygrass varieties tested in a diallel cross. A large number of variety trials were analyzed, including tests of various species of grass and many corn experiments. Much time was spent on analysis of various subjects: the effect of rotation, manure, and fertilizer treatments on the yield of potato tubers; collaborative tests, involving 10 soil laboratories, to study methods of determining iron and aluminum levels in soil; the effects of fertilizer treatments on strawberry size; and the effects of spacing and seeding date on several cereal crops and two hybrid lines of tobacco.

Assistance was given in analyzing and interpreting experiments to study the joint

effects of nematodes and viruses on the yield of a number of horticultural crops. For potatoes, a stem-cutting program was started to investigate the effects of two virus diseases and one fungal disease, singly or in combinations, on the yield of tubers.

Animal Science

Time-series models, both parametric and nonparametric, were used in the examination of data from a study to analyze the patterns of certain physiological measurements of sheep in relation to time. Data on the internal body temperature suggested that there are important periodicities other than that of 24 h. Work on more complex models and on other physiological measurements is in progress.

A program to handle bioassays in which the number of individuals at risk is unknown (Wadley's Problem) was applied to assays, performed by the plaque neutralization method, to characterize strains of the blue-tongue virus.

Advisory work and statistical analyses were carried out on a number of animal nutrition studies, including a series of experiments with swine to determine the effects of high levels of copper on the growth rate, feed conversion efficiency, fatty acid distribution in the subcutaneous region, and deposition of copper in the tissues. Data from studies to compare sources and amounts of protein and sources and amounts of energy in diets of farm animals were analyzed for numerous projects.

Work continued during the past year on a long-term experiment with poultry, to find the effects of selection on components of variance and to examine genetic-environmental interactions. Other assistance to scientists working with poultry included data analysis of studies on management systems and nutrition.

Food Science

Analysis of variance was used to examine the data from an experiment comparing the effect of the enzyme emporase with that of a rennet-pepsin mixture on various properties of Canadian Cheddar cheese. Organoleptic differences decreased as the cheese aged. Most of the other measured variables showed no statistically significant differences. However, conclusive inferences could not be made because of the small sample size. An

experiment comparing Cheddar cheeses made with bovine pepsin and rennet was designed, on the basis of previous information, to enable detection of commercially important differences. Partial analysis of the data has revealed no significant differences among the week-old cheeses. Fat losses, total protein, and nonprotein nitrogen in whey were higher, and cheese yield was lower, for bovine pepsin.

Other investigations included designing experiments to compare analyses, conducted in different locations, of various properties of several kinds of spaghetti; to examine the effectiveness of a new method of measuring the selenium content of food; and to tabulate taste-panel data on flavored milk.

Bioassay

Quantal assays continue to represent the major part of the bioassay work, and several hundred assays have been analyzed and collated. These include studies of the effects of insecticides on nontarget organisms.

The methodology for assays involving Wadley's Problem has been extended, in particular to include two-parameter distributions for the controls; this allows both parameters to reflect environmental differences, such as design features. Collaborative work continued on the assay of the blue-tongue virus by a plaque neutralization method, a case of Wadley's Problem. The assay appears to be subject to high variability, so a series of experiments was designed to seek any changes in laboratory technique that might improve the precision. It has proved desirable to retain a matched serum-treated well for each control, and the within-assay variability has been reduced by use of a higher concentration of virus suspension. However, the variation among replicates persistently dominates, and no way to reduce this effect has yet been found. Fortunately, the assay is simple to set up so that adequate replication is easily attained, but careful design is needed to give due recognition to the variability characteristics. Other work in this field includes an analysis, still in progress, of cross-reactions in several strains, to seek suitable models and to examine the method for use in the classification of viruses.

Numerical Taxonomy

Cassava plants from several countries were classified on the basis of the presence or absence of certain chromatographic spots. Principal component analysis and single-linkage dendrograms did not provide satisfactory clustering for the data. Grouping by two-dimensional chromatographic R_f values also gave a poor match with grouping by morphological characters. Refining the chemical analysis procedures may help in the detection of differences among plants.

Morphological characters as well as chemical constituents were used to classify populations of *Cannabis sativa* L. into different groups. Canonical analysis indicated that a classification based on cultivated versus wild populations and on a certain chemical ratio, to form four groups, was very promising.

A study of characters of the family Chironomidae of the order Diptera by canonical analysis is continuing. Interest is centered on the variation of insects from different geographic areas and the comparison of differences within and between species. Although differences were observed within a single species collected from different geographic areas, similar differences were also found within an individual area at different times.

Analysis of data from a cooperative test for barley in Eastern Canada demonstrated that the joint use of regression analysis and cluster analysis in determining varieties with the same yield potential could be very

effective. The basic idea was to cluster the varieties into groups within which all share a common regression line.

Agricultural System Design and Analysis Group

This new arrangement, formed from the Engineering Research Service, Soil Research Institute, Chemistry and Biology Research Institute, and Statistical Research Service, has provided members of the group with the opportunity to become more aware of the interrelationships among the different systems they have been studying. The group has also provided its members with an excellent framework for sharing their wide range of modeling and mathematical skills. Some problems of mutual interest have related to the identification and application of environmental parameters to the analysis of grass forage production and harvesting systems, and the application of the finite element method as an efficient way to solve numerically the equations arising from the study of agrometeorological and soil systems.

The systems group has also provided a structure whereby research scientists coming from a number of research stations can take advantage of the expertise in modeling and systems science. As part of this cooperative approach, members of the Eastern Canada Feed-Livestock Systems Working Committee met with the group in Ottawa during October to discuss the principles of model development.

PUBLICATIONS

Research

- Baum, B. R., and Lefkovitch, L. P. 1973. A numerical taxonomic study of phylogenetic and phenetic relationships in some cultivated oats, using known pedigrees. *Syst. Zool.* 22:118-131.
- Hardwick, D. F., and Lefkovitch, L. P. 1973. Species separation in the *declarata* group of the genus *Euxoa*, a computer analysis based on structural characters. *Can. Entomol.* 105:501-508.
- James, W. C., Lawrence, C. H., and Shih, C. S. 1973. Yield losses due to missing plants in potato crops. *Am. Potato J.* 50:345-352.
- James, W. C., and Shih, C. S. 1973. Size and shape of plots for estimating yield losses from cereal foliage diseases. *Exp. Agric.* 9:63-71.
- James, W. C., and Shih, C. S. 1973. Relationship between incidence and severity of powdery mildew and leaf rust on winter wheat. *Phytopathology* 63:183-187.
- James, W. C., Shih, C. S., Callbeck, L. C., and Hodgson, W. A. 1973. Interplot interference in field experiments with late blight of potato (*Phytophthora infestans*). *Phytopathology* 63:1269-1275.
- James, W. C., Shih, C. S., Hodgson, W. A., and Callbeck, L. C. 1973. A method for estimating the decrease in marketable tubers caused by potato late blight. *Am. Potato J.* 50:19-23.

Research Station Brandon, Manitoba

PROFESSIONAL STAFF

W. N. MACNAUGHTON, B.Sc., M.Sc., Ph.D.
J. A. REDMOND

Director
Administrative Officer

Animal Science

J. H. STRAIN, B.S.A., M.Sc., Ph.D.
R. L. CLIPLEF, B.Sc., M.Sc., Ph.D.
G. W. DYCK, B.S.A., M.Sc., Ph.D.
I. GARNETT, B.S.A., M.S.A., Ph.D.
A. P. PILOSKI, B.S.A.
G. W. RAHNEFELD, B.Sc., M.Sc., Ph.D.
E. E. SWIERSTRA, B.S.A., M.S.A., Ph.D.

Head of Section; Poultry genetics
Meats physiology
Reproductive physiology
Swine genetics
Poultry production
Beef cattle genetics
Reproductive physiology

Plant Science

R. I. HAMILTON, B.Sc., M.S.A., Ph.D.
L. D. BAILEY, B.S.A., M.Sc., Ph.D.
P. N. P. CHOW, B.S.A., M.A., Ph.D.
R. D. DRYDEN, B.S.A., M.Sc.
A. T. H. GROSS, B.S.A., M.Sc.
A. E. SMID, B.Sc., M.Sc., Ph.D.
E. D. SPRATT, B.S.A., M.Sc., Ph.D.
R. I. WOLFE, B.S.A., B.D.

Head of Section; Corn physiology
Soil-plant relationships
Weed physiology
Crop culture
Forage crops
Plant nutrition
Plant nutrition
Barley breeding

INTRODUCTION

This report is a brief description of research activities in 1973. Research emphasizes breeding and physiology in animal science; and breeding, physiology and management, soil fertility and plant nutrition, cultural practice, and weed control in plant science.

Dr. Ian Garnett, a geneticist, was appointed in September to help increase efforts in swine research.

Dr. A. E. Smid joined the staff in June as a replacement for Dr. E. D. Spratt, who was appointed for a 2-yr term as Canadian coordinator for the India Dryland Project at Hyderabad, India.

Only the highlights of research are presented in this report; for further information concerning details of work discussed, or on related subjects, enquiries should be directed to: Research Station, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef Cattle

Response to selection for yearling weight. Ten years of selection for yearling weight in replicate herds of Shorthorn cattle resulted in genetic increases of 4.8 ± 3.1 and 4.1 ± 3.0 kg/yr in males, and 3.3 ± 2.7 and 2.3 ± 1.5 kg/yr in females. Measured as deviations from an unselected control-line mean, the increases represented 40 to 45% of the absolute increase in yearling weight. The accumulation of selection differential was irregular in the first years of the program but in the last 6 yr it advanced regularly, at rates of 12.1 ± 0.7 and 11.2 ± 0.9 kg/yr for males and 9.1 ± 0.3 and 7.6 ± 0.4 kg/yr for females. Estimates of realized heritability derived from the two herds were 0.49 ± 0.12 and 0.51 ± 0.16 for males, and 0.50 ± 0.11 and 0.29 ± 0.08 for females.

Evaluation of foreign breeds. Feedlot data collected for 3 yr from 844 crossbred calves out of Hereford, Aberdeen Angus, and Shorthorn cows indicated that steers sired by Limousin, Simmental, and Charolais bulls gained 1.17, 1.32, and 1.25 kg/day in a 140-day period. Corresponding data for feed efficiency were 6.55, 6.72, and 6.41 kg feed/kg gain for Limousin, Simmental, and Charolais crossbreds.

Carcass characteristics of crossbred steers. Slaughter and carcass data were collected from 652 crossbred steers weighing 454 kg at slaughter; of this number, 321 were sired by Limousin, 183 by Simmental, and 148 by Charolais bulls. Charolais crossbreds were

younger than Simmental- and Limousin-sired steers at slaughter (397 vs 402 and 422 days). They yielded more hot carcass per day of age (0.68 vs 0.65 and 0.64 kg), a lower percentage of kidney, heart, and pelvic fat (2.37 vs 2.51 and 2.60%), and a higher percentage of defatted lean (64.5 vs 63.1 and 63.8%). The Charolais crossbreds also produced a higher percentage of A1 carcasses (80 vs 69 and 64%).

Limousin crossbreds had a higher dressing percentage than Charolais- and Simmental-sired steers (57.4 vs 57.0 and 55.9%). They produced a larger rib eye (76.4 vs 75.1 and 72.9 cm²) and a higher percentage of A2 carcasses (29 vs 14 and 16%).

Simmental crossbred steers had less fat cover than Charolais and Limousin crossbreds (1.14 vs 1.22 and 1.37 cm) and a larger percentage of B1 carcasses (12 vs 6 and 5%).

Beef production from hybrid females. In 1972, 481 hybrid females were designated for breeding. They represented 10 breed combinations; Limousin, Simmental, and Charolais sires each mated to Hereford, Angus, and Shorthorn cows accounted for nine breed combinations, and a Hereford \times Angus cross was used as a control. Bulls of six breeds were used as sires, Beefmaster and Red Angus with yearling heifers and Limousin, Simmental, Charolais, and Chianina with older cows, in such a way that back-crossing did not occur. In a 63-day breeding season, 476 females (99.0%) were detected in heat and bred by artificial insemination. Pregnancy testing by palpation showed that

401 (83.4%) were in calf, and 395 (82.1%) calved in 1973.

Birth weights (sexes combined) for the three-breed crossbred calves by breed of sire (Beefmaster, Red Angus, Limousin, Simmental, Charolais, and Chianina) were 37.2, 35.0, 39.6, 43.0, 43.0, and 42.8 kg. Corresponding adjusted 200-day weaning weights were 199.8, 194.8, 216.2, 221.2, 231.7, and 225.1 kg. Averaged over sex and breed of sire, the adjusted 200-day weaning weights by breed of sire-of-dam were 189.6, 207.4, 215.2, and 201.0 kg when Hereford, Charolais, Simmental, and Limousin were the four breeds of sire. Numbers were too small to establish the significance of these differences.

Swine

Correlated response to selection for postweaning gain. In nine generations of selection for postweaning gain, the total response to direct selection was 0.03 kg per generation. This was 3.1% of the predicted response. The estimate of genetic correlation between postweaning average daily gain and weaning weight was high and positive (> 1). Total response in feed efficiency to direct selection for gain was -0.58 kg per generation. This was 10% of the predicted response. The estimate of genetic correlation between postweaning gain and feed efficiency was -0.35 .

Epididymal sperm reserves and sperm output. Epididymal sperm reserves were determined by hemacytometric counting in two groups of boars killed immediately (2 min) and 24 h after ejaculation following a period of 5 wk on a 72-h semen collection schedule. Numbers of sperm in the caput, corpus, and cauda epididymides of boars killed immediately after ejaculation were 25.4, 12.0, and 45.0×10^9 . Corresponding numbers for boars killed 24 h after ejaculation were 30.3, 12.6, and 48.9×10^9 . The sperm output for the 20 boars averaged 43.6×10^9 sperm per ejaculate, and it appears that about 78% of the sperm produced by the testes were harvested on a 72-h collection schedule.

Cold stress and testosterone levels. Yorkshire boars housed outside during the winter months at a mean daily temperature of -14°C have higher levels of circulating serum testosterone than similar boars housed in a barn with temperature controlled at 17°C (6.8 vs 3.4 ng/ml). Levels of serum luteinizing hormone were similar for both groups

(0.6 vs 0.5 ng/ml). The difference in testosterone levels may suggest that the hormone has an anabolic function as well as a reproductive one.

Induction of early postweaning estrus. In Lacombe sows weaning their litters after 42 days of lactation, a single injection of pregnant mare's serum gonadotrophin (PMSG) the day after weaning induced an early return to estrus. For 32 sows, the average period from weaning to estrus was 3.9 days (range 2–5 days). A control group of 32 sows averaged 9.9 days to estrus (range 3–41 days) and a third group of 33 sows that received an intramuscular injection of estradiol 17B (E) plus progesterone (P) returned to estrus either early (23 sows at 4.3 days, range 2–8 days) or very late (10 sows at 27.5 days, range 20–59 days). Ovulation rates for sows that responded to treatment were 27.1 for 32 sows treated with PMSG, 17.6 for 23 sows treated with E + P, and 14.6 for 33 control sows. Corresponding 25-day litter sizes were 15.4 for 20 sows treated with PMSG, 14.2 for 19 sows treated with E + P, and 11.9 for 26 control sows.

Chemical composition of fetal fluids at mid-pregnancy. Levels of feed consumption (1.50, 2.25, and 3.00 kg/head daily) did not affect the nitrogen, urea nitrogen, glucose, calcium, potassium, sodium, and magnesium content of allantoic and amniotic fluids of 60-day fetuses in gilts. The nitrogen level was greater in the allantoic than in the amniotic fluid (6.93 vs 3.33 mg/ml), the urea nitrogen level was greater (0.266 vs 0.094 mg/ml), but the glucose level was lower (1.03 vs 1.53 mg/ml). In allantoic and amniotic fluids the levels of sodium were 0.51 and 2.67 mg/ml, potassium 225 and 349 $\mu\text{g/ml}$, calcium 263 and 39.6 $\mu\text{g/ml}$, and magnesium 12.8 and 12.6 $\mu\text{g/ml}$.

Muscle quality in pork by breeds and crosses. In studies involving 3,300 carcasses (Yorkshire, Lacombe, and Lacombe \times Yorkshire) over a 5-yr period, Yorkshire carcasses scored higher than Lacombe and Lacombe \times Yorkshire carcasses for color and texture of lean (3.45 vs 3.07 and 3.22, and 3.10 vs 2.82 and 2.92). Crossbred carcasses had higher marbling scores than Lacombe and Yorkshire carcasses (3.18 vs 3.06 and 3.03).

Poultry

Varieties of feed wheat for laying hens. When individual varieties of feed wheat were the only source of grain in the rations fed to four strains of White Leghorn hens, production among strains ranged from 70 to 86% but differences due to rations were small (78% with the varieties Manitou and Glenlea vs 76% with Pitic 62). Feed efficiency, egg weights, shell quality, and interior quality were unaffected by the variety of wheat. Yolk color was much paler (1.1 vs 4.0 on the color scale) with Glenlea and Pitic 62 than with Manitou, but this was corrected by adding alfalfa meal or synthetic coloring to the diet. When all wheats were assumed to be equal in price, differences in income over feed costs for the various diets were small and insignificant over the 112-day laying period.

Whole oats with tallow for growing pullets. Three Leghorn strains fed whole oats with tallow (8.5% protein), supplemented with minerals and vitamins only, reached sexual maturity 10 days later and gave slightly larger eggs than similar pullets fed a regular rearing ration (14.5% protein). Two of the strains also produced fewer eggs. Mortality of growing pullets was slightly higher on the low-protein diet, but mortality in the laying house and returns over costs of chicks and feed were not affected by the feed treatment during growth.

Effect of vaccination against Marek's disease on growth and performance. When three strains of Leghorns were vaccinated at 1 day old and then reared in an environment free from Marek's disease, egg production, egg weight, sexual maturity, and mortality were not affected by the vaccination. Feed efficiency, however, was improved, so that the income over costs from vaccinated birds was 5 cents per bird higher than that from nonvaccinated birds.

PLANT SCIENCE

Forage Crops

Yield of dry matter and protein from bromegrass-legume mixtures. When two cuts of forage were used to represent hay production by mixtures of bromegrass with various legumes, bromegrass-alfalfa had protein contents of 14.0 and 18.3%, protein yields of

635 and 470 kg/ha, and dry matter (DM) yields of 4,536 and 2,568 kg/ha for the first and second cuts. The mixtures of bromegrass with cicer milkvetch, crownvetch, birdsfoot trefoil, and sainfoin had average protein contents of 8.5 and 12.4%, protein yields of 280 and 73 kg/ha, and DM yields of 3,294 and 589 kg/ha.

Where three cuttings were made to represent pasture production, protein contents for first, second, and third cuttings were 18.6, 20.4, and 23.4%; protein yields were 553, 440, and 362 kg/ha; and DM yields were 2,973, 2,156, and 1,547 kg/ha for bromegrass-alfalfa. Averages for the other mixtures were protein contents, 13.4, 15.6, and 14.0%; protein yields, 323, 151, and 74 kg/ha; and DM yields, 2,410, 968, and 529 kg/ha.

Total yield of DM from bromegrass-alfalfa was greater with the two-cut system than with the three-cut system (7,104 vs 6,676 kg/ha), but slightly less from the other mixtures (3,883 vs 3,907 kg/ha). However, the total yield of protein from all bromegrass-legume mixtures was greater from the three-cut system (1,355 vs 1,105 kg/ha for bromegrass-alfalfa and 548 vs 353 kg/ha for other mixtures).

Effect of delayed cutting and added nitrogen on bromegrass. Bromegrass was fertilized with N at 0, 84, 168, or 252 kg/ha before spring growth began, and cut at weekly intervals from 6 to 10 wk after growth commenced. As the rate of applied N increased, protein content increased from 11.9 to 16.4%, protein yield from 729 to 1,608 kg/ha, and DM yield from 6,126 to 10,025 kg/ha. As the date of cutting advanced, protein content and protein yield decreased from 18.4 to 11.7% and from 389 to 327 kg/ha. However, the yield of DM increased with delayed cutting, from 2,114 to 2,748 kg/ha.

When a second cut was made 9 wk after the start of the series of first cuts (5 wk after the last cut of the series), the protein content for treatments with N at 0 to 168 kg/ha averaged 13.7%, whereas it was 16.0% for the treatment with 252 kg N/ha. For the second cut 5 wk after the first series, protein content was 15.1% (protein and DM yields 356 and 2,358 kg/ha) compared with a protein content of 13.8% (protein and DM yields 433 and 3,138 kg/ha) for the second cut 9 wk after the first series.

Soil and plant analyses for predicting quality and quantity of alfalfa production. Significant yield increases were obtained when alfalfa was fertilized annually with phosphorus and sulfur on Gray Luvisols, or with phosphorus and potassium on coarse-textured soils. Plant analyses showing N, P, K, and S at 3.0, 0.2, 2.0, and 0.2% and soil analyses showing P and K at 22 and 672 kg/ha indicated optimum DM yields of good-quality hay. Significant correlations were found between percentages of N and K in plants ($r = 0.93$), between N and P ($r = 0.57$), and between N and S ($r = 0.82$). The percentage of N in plants increased as the percentage of K increased up to 2.5%. Plants with less than 1.6% K in the aboveground portions were subject to winterkill.

Oilseed Crops

Soybean production. In preliminary trials to evaluate the potential for soybeans in an adverse environment, 36 varieties and breeding lines representing test material from Guelph, Ont., Morden, Man., and Ottawa were planted on May 24 and 25 and harvested on October 10 and 24. Tests averaged 10.1–18.3 q/ha and the highest-yielding line produced 22.2 q/ha. In another preliminary trial, soybeans showed no response to fertilizer N on a soil with a high level of available N. Yields were 18.0 and 17.3 q/ha on plots treated with N at 0 and 112 kg/ha.

Fertilization of flax with micronutrients. Growth chamber studies with flax grown on Waskada clay loam indicate that micronutrients may be deficient when high levels of P are applied. The addition of a micronutrient mixture containing copper and zinc plus fertilizer P increased the DM yield of flax at the 50% flowering stage, but micronutrients or fertilizer P alone did not increase yields in comparison with the unfertilized control.

Asulam mixtures for control of weeds in flax. Asulam at 1.12 kg/ha gave good control of wild oats and green foxtail but did not suppress lamb's-quarters and redroot pigweed. Mixtures of asulam with other herbicides increased control of broad-leaved weeds but tended to reduce control of wild oats; the reduction ranged from slight when asulam was mixed with bromoxynil plus MCPA at 0.56 kg/ha to moderate when mixed with MCPA at 0.28 kg/ha. All asulam and asulam mixtures increased yields of flax; increases ranged from 8% with asulam plus

MCPA to 124% with asulam plus bromoxynil and MCPA.

Dinitroaniline herbicides for control of weeds in rape. Four dinitroaniline herbicides, BAS-3921 (BASF Corp.), CGA-10832 (Ciba-Geigy Canada Ltd.), USB 3584 (U.S. Borax and Chemical Corp.), and trifluralin, were each disc-incorporated into the top 10 cm of soil at 1.4 kg/ha before rape was seeded. They all gave good control of wild oats and green foxtail and produced significant increases, of 85, 83, 155, and 154%, in seed yield in comparison with untreated plots.

Cereal Crops

Barley breeding. Improved yield, agronomic excellence, disease resistance, and feed and malting quality of six-row barley continued to receive emphasis. Some advanced lines performed well in extensive tests and preliminary data indicated that some have outstanding malting quality. Work continued on the development of lines that carry resistance to septoria leaf blotch and one of these, a malting type, ranked first in yield trials in 1973. Several breeding lines carry the *Un8* gene for resistance to loose smut and there is hope that this gene can replace those of Jet, which have been found susceptible to a new race of loose smut.

Breeding lines from crosses of high-yielding feed varieties are under development, and genes that condition high levels of amylopectin and lysine have been introduced into the program. Two genetic marker stocks have been isolated, each with at least one gene on each chromosome. One stock carries 11 dominant genes and the other carries the recessive alleles.

Solution nitrogen for barley and wheat. Solution N increased yields significantly when applied at the two- and four-leaf stages of barley and wheat at rates up to 67.2 kg/ha for barley on sandy soil and up to 44.8 kg/ha for wheat on sandy and clay loams. Yields of protein were increased by solution N at rates up to 89.6 kg/ha. N solutions combined with herbicide treatments produced satisfactory results.

Herbicides that improved barley and wheat production with or without N solutions included triallate for wild oats, trifluralin for wild oats and green foxtail, TCA for green foxtail, and 2,4-D and related chemicals for broad-leaved weeds.

Physiological behavior of herbicides absorbed by wheat roots. The absorption of TCA by wheat roots is an energy-dependent active process. Studies with TCA-¹⁴C indicate that absorption was influenced by aeration, metabolic inhibitors, and energy promoters. Linuron absorption appears to be mainly passive, as judged by low sensitivity to oxygen deficiency, lack of a saturation effect, and slight effects of metabolic inhibitors and energy promoters.

Corn production and management. Heat unit (HU) accumulation was above normal (2,265 vs 2,150), but because germination was slower than normal the effective HU accumulation from emergence to maturity was 2,098. Evaluation of existing lines and varieties under relatively adverse conditions continued to reveal a wide range of breeding material. Among characteristics of significance to plant breeders, stalk strength was an important variable at the Station and throughout the corn growing area. The goal of 11 t/ha for DM production was met in four field-scale trials comprising 22.7 ha of corn (yield average 11.2 t/ha, range 8.7–16.4 t/ha) grown on soils ranging from sandy loam to clay loam. Grain yields averaged 44 q/ha (range 31–53 q/ha), somewhat below the goal of 63 q/ha. The effect of shelter on corn production was shown by the trials at Indian Head, Sask., where yields were 37.7 q/ha in a shelterbelt area but only 5.0 q/ha at an open site.

Soil moisture and nitrogen for corn and barley production. Yields of 24.8 q/ha were obtained from grain corn grown on fine sandy loam without additional N, where plots were prevented from receiving natural precipitation during the fall and winter

before planting. Yields increased to 45.6 q/ha where 100 kg N/ha was applied and the plots received natural precipitation, and to 50.3 q/ha where N was applied at 100 kg/ha and plots were irrigated. On clay soil, corn yields from corresponding treatments were 39.5, 45.6, and 46.8 q/ha. Barley yields on a sandy loam ranged from 15.7 q/ha, without added N and without natural precipitation, to 22.5 q/ha for 100 kg N/ha plus irrigation, to 34.9 q/ha for 100 kg N/ha and natural precipitation.

Preemergence weed control in corn. S-6176 (Gulf Oil), sprayed on the soil at 5.3 kg/ha and incorporated with a disc before corn (Pride 102) was planted gave good control of wild oats and green foxtail. DM yields of silage from sprayed, hand-weeded, and untreated plots were 7.7, 9.4, and 1.3 t/ha. EPTC at 4.5 kg/ha, sprayed on soil and incorporated with a disc before planting, controlled wild oats, green foxtail, and lamb's-quarters (DM yield 8.2 t/ha). EPTC at 3.4 kg/ha applied before emergence, followed by dicamba at 0.3 kg/ha after emergence, controlled wild oats, green foxtail, lamb's-quarters, and redroot pigweed (DM yield 8.7 t/ha). S-6176 and EPTC represent improved treatment for weed control in corn and no effects of residues were noted on subsequent crops of oats.

Sorghum introductions. Sorghum lines from the CIMMYT and Morden programs were screened for photosensitivity and performance. The sorghums were similar to corn in response to climate and several lines showed good adaptation. Grain yields with minimal fertilizer input reached 37 q/ha, and forage sorghums in field trials averaged 9.6 t DM/ha.

PUBLICATIONS

Research

- Bailey, L. D., and Beauchamp, E. G. 1973. Gas chromatography of gases emanating from a saturated soil system. *Can. J. Soil Sci.* 53:122-124.
- Bailey, L. D., and Beauchamp, E. G. 1973. Effects of temperature on NO₃⁻ and NO₂⁻ reduction, nitrogenous gas production, and redox potential in a saturated soil. *Can. J. Soil Sci.* 53:212-218.
- Bailey, L. D., and Beauchamp, E. G. 1973. Effects of moisture, added NO₃⁻ and macerated roots on NO₃⁻ transformation and redox potential in surface and subsurface soils. *Can. J. Soil Sci.* 53:219-230.
- Chow, P. N. P. 1973. Wheat tolerance to TCA for green foxtail control. *Weed Sci.* 21:238-240.
- Gillis, A. T., Eskin, N. A. M., and Cliplef, R. L. 1973. Fatty acid composition of bovine intramuscular and subcutaneous fat as related to breed and sex. *J. Food Sci.* 38:408-411.

- Gowe, R. S., Lentz, W. E., and Strain, J. H. 1973. Long term selection for egg production in several strains of White Leghorns: performance of selected and control strains including genetic parameters of two control strains. *Proc. 4th Eur. Poult. Conf. London.* pp. 225-245.
- Gross, A. T. H. 1973. Effects of floret manipulation on self-fertilization in species of sweet clover. *Can. J. Plant Sci.* 53:801-804.
- Newman, J. A., Rahnefeld, G. W., and Fredeen, H. T. 1973. Selection intensity and response to selection for yearling weight in beef cattle. *Can. J. Anim. Sci.* 53:1-12.
- Rahnefeld, G. W. 1973. Mass selection for post-weaning growth in swine. III. Correlated response in weaning weight and feed efficiency to recurrent selection for postweaning average daily gain in swine. *Can. J. Anim. Sci.* 53:173-178.
- Read, D. W. L., Spratt, E. D., Bailey, L. D., Warder, E. G., and Ferguson, W. S. 1973. Residual value of phosphatic fertilizer on Chernozemic soils. *Can. J. Soil Sci.* 53:389-398.
- Spratt, E. D. 1973. The effect of ammonium and urea phosphates with and without a nitrification inhibitor on growth and nutrient uptake of wheat. *Soil Sci. Soc. Am. Proc.* 37:259-263.
- Swierstra, E. E. 1973. Influence of breed, age, and ejaculation frequency on boar semen composition. *Can. J. Anim. Sci.* 53:43-53.
- Miscellaneous**
- Bailey, L. D. 1973. Soil test and plant analysis are a means of predicting quality and quantity alfalfa production. *Proc. Man. Soc. Soil Sci., Man. Dep. Agric.* pp. 142-147.
- Bailey, L. D., and Gross, A. T. H. 1973. Land resource for forage crop production in Manitoba. *Man. Agron. Proc. Annu. Conf., Man. Dep. Agric.* p. 57.
- Baron, V., Shaykewich, C. F., and Hamilton, R. I. 1973. Progress report on corn heat unit study. *Proc. Man. Soc. Soil Sci., Man. Dep. Agric.* pp. 55-64.
- Chow, P. N. P. 1972. Improvement of linuron-MCPA mixture in weed control in wheat and flax. *Proc. 27th N. Cent. Weed Control Conf., Winnipeg.* pp. 43-45.
- Chow, P. N. P. 1972. Asulam—a new wild oat herbicide in flax. *Proc. 27th N. Cent. Weed Control Conf., Winnipeg.* p. 39.
- Dryden, R. D. 1972. The control of weeds in corn in Western Canada. *Proc. 27th N. Cent. Weed Control Conf., Winnipeg.* p. 19.
- Dryden, R. D. 1973. Residual effect of herbicides on crops. *Proc. Man. Soc. Soil Sci., Man. Dep. Agric.* pp. 39-46.
- Dyck, G. W. 1973. Physiological aspects of reproductive efficiency in swine. *Can. Agric.* 18(2):37-39.
- Gross, A. T. H. 1972. Grass-legume competition studies. *Proc. Can. Soc. Agron.* p. 3.
- Gross, A. T. H. 1973. Selecting productive hay mixtures. *Can. Agric.* 18(1):32.
- Gross, A. T. H., Bailey, L. D., Storgaard, A. K., and Clark, K. W. 1973. Agronomic aspects of land use by forage crops—potential of species and varieties, fertilizers, and weed control. *Proc. Annu. Conf. Man. Agron., Man. Dep. Agric.* pp. 63-64.
- Gross, A. T. H., and Dorrell, D. G. 1973. *Onosmodium*—a native perennial with oilseed potential. *Proc. Annu. Conf. Man. Agron., Man. Dep. Agric.* pp. 103-104.
- Hamilton, R. I. 1973. Corn is following livestock expansion in Manitoba. *Can. Agric.* 18(4):3-5.
- Hamilton, R. I. 1973. Corn management. *Proc. Man. Soc. Soil Sci., Man. Dep. Agric.* pp. 47-54.
- Hopkins, L. A., Smith, R. E., and Spratt, E. D. 1973. Soil map of Research Station, Brandon. *Can.-Man. Soil Survey. Soil Res. Inst., Ottawa.* 1 p.
- Smid, A. E. 1973. Effect of temperature, organic matter and soil conditioning on denitrification in soil. *Proc. Man. Soc. Soil Sci., Man. Dep. Agric.* pp. 154-159.
- Spratt, E. D. 1973. Winter wheat in northern Manitoba and Saskatchewan. *Can. Agric.* 18(3):11-12.

Research Station Morden, Manitoba

PROFESSIONAL STAFF

E. D. PUTT, B.S.A., M.Sc., Ph.D.

Director

Crop Science Section

D. G. DORRELL, B.S.A., M.Sc., Ph.D.

Head of Section; Oilseed quality

S. T. ALI-KHAN,¹ B.S.A., M.Sc., Ph.D.

Pea breeding

C. G. CAMPBELL, B.S.A., M.Sc., Ph.D.

Buckwheat breeding

W. O. CHUBB, B.Sc., D.Sc.

Herbicides

B. B. CHUBEY, B.S.A., M.Sc., Ph.D.

Carbohydrate quality

H. ENNS, B.S.A., M.Sc., Ph.D.

Sunflower breeding

J. E. GIESBRECHT, B.S.A., M.Sc., Ph.D.

Grain corn breeding

G. H. GUBBELS, B.S.A., M.S.A., Ph.D.

Physiology and management

J. A. HOES, B.S.A., M.S.A., Ph.D.

Oilseed crop pathology

E. O. KENASCHUK, B.S.A., M.Sc., Ph.D.

Flax breeding

W. A. RUSSELL, B.S.A.

Potato breeding

M. D. STAUFFER, B.Sc. (Agr.), M.Sc., Ph.D.

New crops

E. D. P. WHELAN, B.S.A., M.S.A., Ph.D.

Sweet corn and cucumber breeding

R. C. ZIMMER, B.Sc., Ph.D.

Pathology of peas

Ornamentals and Fruit Section

W. A. CUMMING, B.S.A., D.Sc.

Head of Section; Ornamentals

W. G. RONALD,² B.S.A., M.Sc.

Ornamentals breeding

Departure

C. WALKOF, B.S.A., M.Sc., Ph.D.

New crops

Retired June 1973

VISITING SCIENTIST

J. V. GOUD, Ph.D.

Sunflower breeding

Trainee; All Indian Coordinated Research Project
for Dryland Agriculture

¹On transfer of work to John Innes Institute, Norwich, England, July 1973 to July 1974.
²On educational leave.

INTRODUCTION

This report summarizes research in several field crops that are often termed special crops in Canadian agriculture, and in horticulture at the Research Station, Morden, Man. Some of the main items of 1973 include: identification of a selection of buckwheat, an introduced variety of sunflowers, and a selection of chrysanthemum that merit release; a high yield of geraniol oil from a strain of *Monarda*; discovery of a new race of flax rust capable of attacking the varieties that make up over 90% of the acreage of flax planted in Canada; and finding that leaf buds provide a rapid means of propagating roses. The mailing address of the establishment is Research Station, Research Branch, Agriculture Canada, Box 3001, Morden, Man. R0G 1J0.

Eric D. Putt
Director

FIELD CROPS

Buckwheat

Breeding. The selection MB-1 has seed 25% larger than Tokyo and has produced yields equivalent to Tokyo in 3 yr of cooperative testing. This selection will be recommended for licensing. A dwarf plant habit has been found to be monogenic and closely linked with the incompatibility locus. A second dwarf has been isolated and inheritance of the character is under study.

Disease. The large, circular, chlorotic-type lesions observed on foliage in 1972 appeared again in 1973. In some fields about half the foliage was affected. Other leaf symptoms observed were tan, stipplelike spots and viruslike, mosaic areas.

Management. Five growth-regulating chemicals and two antitranspirants were applied twice at three rates during the flowering period to determine their effect on seed set. No differences were recorded in seed yield, but succinic acid-2,2-dimethylhydrazide (SADH) increased seed size.

Corn

Breeding. Morden 71307, licensed as Warwick TX17, outyielded Morden 67 by 2.5 quintals/ha, and had 2.5% less moisture and considerably less stalk breakage. The Morden inbred CM5 was a parent of several very early maturing hybrids with good yielding ability. Some of these silked 5 days earlier than Warwick SL209. Single-cross hybrids were also produced that equaled Morden 67 in maturity but yielded 27% higher. Progenies from the single cross B14 \times CMV₃ have

figured prominently in many superior hybrids. In addition, hybrids resulting from crosses between sister lines originating from this cross also performed well. This may be due to the distant relationship between the original parents.

Morden hybrids that were composed only of North American inbreds matured very early in France and Germany. However, they showed considerable stalk breakage. On the other hand, hybrids composed of only European inbreds tended to mature late and dry slowly at the Station. Hybrids of Morden and European inbreds tended to resolve these problems at both locations. More efforts will be directed toward the development of this type of hybrid.

Field Peas

Breeding. Triumph, a variety with large green seed, was licensed in 1973. It is well adapted to Manitoba and Saskatchewan. In cooperative tests from 1970 to 1973, Triumph outyielded Century and Trapper by 10% and Delwiche Scotch Green by 20%. Triumph is similar to Century in maturity and disease resistance, but is slightly poorer in cooking quality.

Disease. Pea foliage infected with *Ascochyta pinodes* L. K. Jones was retained in the field on the soil surface and buried in the soil. Samples from both sites were virulent 4 yr later. The effect of temperature was studied on the survival of an isolate from each of the three *Ascochyta* species pathogenic on field peas and an isolate of *Ascochyta fabae* Speg. from fababean. After 8 mo none had survived at 35°C, *A. pinodes* and *A. pisi* Lib. survived at 25°C, and *A. pinodes*, *A. pisi*, and

A. pinodella L. K. Jones survived at 20°C. All species tested were viable at 16°C and lower. *A. fabae* apparently is not able to survive at warmer temperatures.

Based on an epicotyl test for assessing pathogenicity, most isolates of *Ascochyta* from field peas were rated weakly pathogenic on fababean and one was rated as moderately pathogenic. With the same test, isolates of *A. fabae* from fababean were rated weakly pathogenic on fababean and very weakly pathogenic on field peas. Hence, these two crops should not be planted in adjoining fields or used consecutively in a rotation. The reaction of an additional 284 pea introductions to *A. pinodes* showed that only 8 were as resistant to *A. pinodes* as the cultivar Century, or were more resistant. Another three, after being selfed for four generations, were 10–13% more resistant than Century.

Management. Century and Trapper field peas were irrigated three times during the growing season. Seed yield was increased an average of 23.7%, but protein percentage and seed size were not affected.

NEW CROPS

Carbohydrate Crops

Evaluation. Varying combinations of fertilizer and irrigation rates did not affect yields and fructose content of Jerusalem artichoke, *Helianthus tuberosus* L., and chicory, *Cichorium intybus* L. The optimum harvest period for both artichoke and chicory was found to be late September to early October based on tuber and root yields and reducing sugar content.

Diseases and pests. Downy mildew caused by *Plasmopara halstedii* (Farl.) Berl. & de Toni occurred on a few plants of Jerusalem artichoke in plots here; it is a new host record for Manitoba. The sunflower beetle, *Zygotogramma exclamationis* (Fabricius), caused considerable damage in *Helianthus annuus* L. 'Peredovik' but almost none in adjacent rows of Jerusalem artichoke.

Protein Crops

Evaluation. The protein content of seeds varied widely among the pulse crops under test: lentils, *Lens esculenta* Moench, 20.5–27.5%; lupines, *Lupinus albus* L., 32.6–37.9%; mung beans, *Phaseolus aureus* Roxb.,

23.2–26.3%; adzuki beans, *P. angularis* Wight, 21.2–24.9%; fababeans, *Vicia faba* L., 27.9–31.6%; *Lathyrus* sp., 27.4–43.2%; and other beans, *P. vulgaris* L., 20.6–29.3%.

Management. With 15-cm row spacings, the highest yields were obtained from adzuki beans when seeded in mid-May and from mung beans when seeded in late May. The highest yield of lentils was obtained from a May 14 seeding in 15-cm row spacings and the application of N at 33.6 kg/ha and P at 44.8 kg/ha.

Essential Oil Crops

Evaluation. An extremely high geraniol oil content of 95.0%, an oil recovery of 0.358% from the foliage, and a yield of 81.5 kg/ha were obtained from a sweet monarda seedling, *Monarda fistulosa* L. var. *menthaefolia* (Graham).

OILSEED CROPS

Flax

Disease. A most important discovery was that of a new race of rust, *Melampsora lini* (Ehrenb.) Lév., that attacks Noralta, Norland, Redwood, Redwood 65, and Rocket, cultivars with resistance gene N¹ and hitherto resistant to North American rust. The new race, designated 370, occurs in southern Manitoba, west central Saskatchewan, and the adjoining flax-growing regions of the USA.

Breeding. The cultivars Noralta, Norland, and Redwood 65, which are susceptible to race 370, comprised 93% of the flax acreage in the Prairie Provinces in 1973. Only Raja and Linott, a cultivar grown in Quebec, are resistant to the new race of rust. Linott, in a date-of-seeding test at the Station from 1971 to 1973, performed equally well in early and late seeding. It exceeded the yield of Noralta and Raja by more than 15% when sown after May 28. Linott is similar to Noralta in maturity, but has a much higher oil content and is more resistant to lodging. FP 597, an experimental line in the cooperative test, is resistant to race 370 and is a potential replacement for Redwood 65.

Management. Three growth regulators, SADH, chlormequat, and BAS 0660 (BASF Canada Ltd.), were applied at two rates to

flax at an early stage of growth. All treatments reduced plant height, especially the higher rates of SADH and chlormequat. SADH treatments increased seed size and oil percentage. Because there was no lodging in any plots, the effects of the chemicals on this characteristic could not be evaluated. Yields were not affected.

Quality. The color of linseed oil was found to be significantly influenced by the cultivar and the location of the planting. However, some breeding lines produced a light-colored oil regardless of location or year of production. Accelerated yellowing tests do not indicate a relationship between raw-oil color and film color after drying.

Lower oil content, iodine number, and content of linoleic and linolenic acids were characteristic of oil from seeds produced on plants grown in the field that were infected with wilt, *Fusarium oxysporum* Schlecht. f. *lini* (Bolley) Snyder & Hansen. Similar results were obtained in the growth chamber where the effect of premature ripening, often associated with flax wilt, was minimized.

Herbicide susceptibility. Several flax strains were rated for susceptibility to MCPA over 3 yr. The ratings were based on the degree of injury, chiefly epinasty, or recovery from injury, during the week after treatment. This type of field test proved not to be of value, even for preliminary screening of flax strains for susceptibility to a herbicide.

Sunflowers

Breeding. Licensing of Sputnik, an introduction from the USSR, is planned. In 3 yr of tests in Western Canada, Sputnik yielded 3% more seed and 10% more oil than Peredovik. The oil content was 47.5% compared with 43.9% for Peredovik. Maturity and disease reaction were similar to Peredovik.

Results from three experimental F_1 single-cross hybrids showed that large increases over Krasnodarets in both seed yield and oil content can be achieved without sacrificing earliness. One hybrid had an oil content 2% higher than Krasnodarets and produced 73% more oil per hectare. The other two hybrids bloomed 1–2 days later than Krasnodarets and produced 82% and 127% more oil per hectare. All of these hybrids are rust resistant and appear to offer scope for selecting for verticillium resistance. Further, all hybrids either embody a cytoplasmic male sterile and

fertility restoring system or can quickly have this feature added to the parental lines.

Diseases. Premature ripening, ascribed primarily to *Verticillium dahliae* Kleb. and *Sclerotinia sclerotiorum* (Lib.) de Bary, was widespread in Manitoba and reduced seed yields. Much less sclerotinia foot rot was found in INRA 4701 and INRA 7702, French cultivars reputedly tolerant of sclerotinia head rot. This supplements the findings of 1972 that breeding for tolerance to foot rot is feasible. The perfect stage of *S. sclerotiorum* occurred naturally in Manitoba. This is a new field record for Canada. It accounts for the unexpected occurrence of the disease on the stems and heads of plants, and is an important consideration in disease studies. Sclerotinia disease or white mold, apparently arising from airborne ascospore infection, occurred in lentils, navy beans, and green and wax-pod canning beans.

Field observations on downy mildew caused by *Plasmopara halstedii* (Farl.) Berl. & de Toni confirm conclusions reported in 1972 that high moisture near seeding time promotes the disease.

Resistance to yellows, a systemic disease caused by an unidentified species of *Phialophora*, appears to be conditioned by two genes, one of which is dominant.

Quality. The chlorogenic acid content of dehulled and defatted sunflower meal was affected by environment and genotype. The level of chlorogenic acid declined when planting was delayed, and when sunflowers were grown at dry locations. The rate of synthesis and deposition of chlorogenic acid and total lipids closely paralleled one another. Considerable variability in chlorogenic acid content was found in the world collection, indicating that breeding for low levels of this acid may be feasible.

Weed control. Cobex (U.S. Borax and Chemical Corp.) has been registered for commercial use in sunflowers. Preplant treatment with this herbicide at 1.05 kg/ha incorporated to a depth of about 10 cm gave good control of wild oats. BAS 3921 (BASF Canada Ltd.) and CGA-10832 (Ciba-Geigy Canada Ltd.) have given promising results for selective control of the same range of weeds as trifluralin. Small-plot tests showed the need to use postemergence harrowing after preplant treatment with trifluralin, for adequate weed control when crucifers such

as wild mustard or stinkweed are a serious problem.

VEGETABLE CROPS

Cucumbers

Breeding. Three Morden F_1 gynoeocious pickling-cucumber hybrids, which are extremely early and resistant to scab and cucumber mosaic virus, gave good to excellent yields at populations of 29,600–247,000 plants/ha at different sites in Canada and the USA. Two of the hybrids will be released in 1974.

Linkage studies between an induced male sterile, ms_2 , and seven other recessive characters revealed repulsion linkage ($.215 \pm .043$) between ms_2 and *glb*-glabrate.

Field tests of lines selected for ability to germinate under cool conditions indicated positive results in selection for this trait. The average number of heat units, using a base temperature of 14°C, for 50% emergence of selections was one-half that of unselected material.

Potatoes

Breeding. The high-quality chipping cultivar Norchip, from the North Dakota breeding program, was licensed and has rapidly taken over most of the prairie chipping-potato acreage. It falls short of an ideal chipping potato in susceptibility to silver scurf, *Helminthosporium atrovirens* (Harz) Mason & Hughes, and occasionally produces dark-colored chips when reducing sugars are low.

Sweet Corn

Breeding. Twenty-eight of 58 Morden hybrids selected in 1972, and 38 of 105 new hybrids, were retained for further testing. Although several of the hybrids are unsatisfactory for processing, they are extremely early and will be evaluated for the fresh market.

ORNAMENTALS

Breeding

One new garden chrysanthemum cultivar was described and named. *Chrysanthemum* 'Morden Delight' survived the past two test winters in excellent condition when many of

the standard cultivars were severely damaged or killed. Its fully double bronze flowers (R.H.S. 171A) 5 cm in diam are freely produced after early September. The individual plants form a compact mound, 5 dm in height by 6.7 dm in width. This new cultivar will be released through the Canadian Ornamental Plant Foundation.

The search continues for lines, clones, or other forms of garden chrysanthemums to produce uniform progenies from seed. Color counts on over 1,100 controlled-cross seedlings showed that both white and yellow clones can produce very different ratios from a variety of combinations and that the yellow is complexly inherited. Clones breeding pure for white can best be identified by crossing to yellow rather than white of an unknown genotype. Bronze to red shades appear to be caused by shades of purple on a yellow base; therefore obtaining a clone breeding pure for purple presents a similar problem plus the stabilization of the purple color. Identifying superior parents and combinations by crossing seems more likely to achieve the objective than attempting to produce lines of uniform color and desirable plant type by inbreeding.

Chromatographic studies on the identification of red-color pigments, particularly the anthocyanins reported in 1972, in roses were continued. Flowers from 599 individual plants of species, cultivars, and selections have been analyzed by paper chromatography. As a result of these studies, the genetic control of flower color in the genus *Rosa* is being recorded and used in conjunction with the breeding program for hardy roses being conducted at the Station.

Hybrid selections that will soon be released as new cultivars include two *Monarda*, one *Physostegia*, one *Crataegus*, one *Syringa*, and two *Rosa*.

Diseases

A survey of rust, *Puccinia menthae* Pers., on both ornamental and geraniol selections of *Monarda* hybrids revealed distinct resistance in some selections. Similarly resistance to mildew, *Erysiphe polygoni* DC. ex M  rat., was reported in 1971. Hence breeding for resistance to these two fungal diseases appears possible. Another rust, *Puccinia pelargonii-zonalis* Dodge, attacked the cultivars 'Red Perfection' and 'Snowmass' of the common bedding geranium *Pelargonium hortorum* Bailey, in home gardens at Morden.

This is the first published record of this disease in Canada. Apparently the pathogen was imported on cuttings from California.

Arboretum

Reorganization and additions to the plantings continue in the arboretum, which occupies 24.3 ha (60 ac) and contains 7,391 plants of 2,776 taxa of trees and shrubs. It provides source material, a valuable gene pool for breeding and taxonomic programs, and information on hardiness.

Propagation

Leaf-bud cuttings under intermittent mist are a means of rapidly propagating roses. A total of 160 cuttings of three cultivars were taken on June 5. Of these, 86% grew into plants averaging 4.6 dm by fall and many had three stems. The number of cuttings can be increased five to seven times over conventional softwood cuttings by using leaf-bud cuttings.

PUBLICATIONS

Research

Ali-Khan, S. T. 1973. Triumph field peas. *Can. J. Plant Sci.* 53:697-698.

Ali-Khan, S. T., and Youngs, C. G. 1973. Variation in protein content of field peas. *Can. J. Plant Sci.* 53:37-41.

Basu, P. K., Crete, R., Donaldson, A. G., Gourley, C. O., Haas, J. H., Harper, F. R., Lawrence, C. H., Seaman, W. L., Toms, H. N. W., Wong, S. I., and Zimmer, R. C. 1973. Prevalence and severity of diseases of processing peas in Canada, 1970-71. *Can. Plant Dis. Surv.* 53:49-57.

Dorrell, D. G. 1973. Controlling plant height in sunflowers with growth retardants. *Can. J. Plant Sci.* 53:417-418.

Dorrell, D. G. 1973. The effect of unusual field weathering on the quality of flax seed. *Can. J. Plant Sci.* 53:907-910.

Hoes, J. A., Putt, E. D., and Enns, H. 1973. Resistance to verticillium wilt in collections of wild helianthus in North America. *Phytopathology* 63:1517-1520.

Ronald, W. G., and Cumming, W. A. 1973. Compatibility and growth of columnar European aspen on poplar rootstocks. *Proc. Int. Plant Propag. Soc.* (1971) 21:437-441.

Steele, J. W., and Ronald, W. 1973. Phytochemistry of the Salicaceae. VI. The use of a gas-liquid chromatographic screening test for the chemotaxonomy of *Populus* species. *J. Chromatogr.* 84:315-318.

Steele, J. W., Ronald, W., and Bolan, M. 1973. Phytochemistry of the Salicaceae. V. The use of a gas-liquid chromatographic screening test to detect phytochemical variations in *Populus deltoides* Marsh. *J. Chromatogr.* 84:309-314.

Whelan, E. D. P. 1973. Inheritance and linkage relationship of two radiation-induced seedling mutants of cucumber. *Can. J. Genet. Cytol.* 15:597-603.

Whelan, E. D. P., and Chubey, B. B. 1973. Chlorophyll content of new cotyledon mutants of cucumber. *HortScience* 8:30-32.

Walkof, C. 1973. Redstaker—A new staking tomato. *Can. J. Plant Sci.* 53:363.

Walkof, C., Anderson, R. H., and Allen, H. T. 1973. Three bush-type tomato cultivars: Melfort, Booster, and Pembina. *Can. J. Plant Sci.* 53:643-644.

Miscellaneous

Chubb, W. O., Dorrell, D. G., Enns, H., and Hoes, J. A. 1972. Sunflower research: progress report 1972. 5th Int. Sunflower Conf., Clermont-Ferrand, France. pp. 477-480.

Cumming, W. A. 1973. Newer herbaceous perennials. *The 1973 Prairie Garden*. pp. 68-69.

Cumming, W. A. 1973. New woody ornamentals. *Can. Agric.* 18(3):28-29.

Cumming, W. A. 1973. Breeding hardy woody ornamentals. *Annu. Rep. Ornamental Plant Breed. Comm. Am. Soc. Hortic. Sci.* pp. 5-8.

Dorrell, D. G. 1972. Early swathings of flax does not lower seed or oil quality. *Canadex* 148.50.

Dorrell, D. G. 1972. Modification of fatty acid composition in flax. *Proc. Flax Inst. U.S.* 42:21-22.

Dorrell, D. G., and Kenaschuk, E. O. 1973. Effect of weathering on flax seed. *Canadex* 148.50.

Enns, H. 1972. Fertility restorers. 5th Int. Sunflower Conf., Clermont-Ferrand, France. pp. 213-215.

- Gubbels, G. H. 1973. Broccoli production can be mechanized. Canadex 252.50.
- Gubbels, G. H. 1973. Chemical pruning of Brussels sprouts. Canadex 252.24.
- Gubbels, G. H. 1973. Frost protection by sprinkler irrigation in the far north and plastic mulch for cabbage production. Canadex 250.21.
- Hoes, J. A. 1972. Crop rotation and disease considerations. Annu. Conf. Manit. Agron., Brandon, Man. pp. 70-71.
- Hoes, J. A. 1972. Diseases of sunflowers. Proc. Can. Barley and Oilseeds Conf., Winnipeg, Man., pp. 106-107.
- Hoes, J. A. 1973. Planning necessary for crop rotation. Manit. Cooperator. Mar. 8. p. 22A.
- Marshall, H. H. 1973. Coral bells. The 1973 Prairie Garden. pp. 80-81.
- Marshall, H. H. 1973. Index seminum 1972. Research Station, Morden, Man. 14 pp.
- Marshall, H. H. 1973. Rose breeding. Can. Nurseryman. May. pp. 6-7 and 20-21.
- Marshall, H. H. 1973. Rose breeding for the prairies. Can. Agric. 18(4):24-25.
- Putt, E. D. 1972. Sunflower seed production. Can. Dep. Agric. Publ. 1019. Revised. 30 pp.
- Ronald, W. G., and Ascher, P. D. 1973. Self compatibility in *Chrysanthemum morifolium* Ramat. Incompatibility Newsl. No. 3. pp. 27-29.
- Russell, W. A., and Chubey, B. B. 1973. Chip color evaluation. Canadex 258.70.
- Walkof, C. 1973. The search for new farm crops. Can. Agric. 18(2):34-36.

Research Station Winnipeg, Manitoba

PROFESSIONAL STAFF

W. C. McDONALD, B.S.A., M.Sc., Ph.D.

Director

Scientific Support

K. D. OLIVER, B.A., B.L.S.

Librarian

W. ROMANOW, B.S.A., M.Sc.

Scientific Liaison Officer

Cereal Breeding Section

K. W. BUCHANNON, B.S.A., M.Sc., Ph.D.

Head of Section; Barley breeding
and genetics

R. J. BAKER, B.S.A., M.Sc., Ph.D.

Quantitative genetics

V. M. BENDELOW, B.Sc., M.Sc., Ph.D.

Cereal chemistry

D. BROWN, B.S.A., M.Sc.

Oat breeding

A. B. CAMPBELL, B.S.A., M.Sc., Ph.D.

Common wheat breeding

E. M. CZARNECKI, B.S.A.

Common wheat breeding

P. L. DYCK, B.S.A., M.Sc., Ph.D.

Wheat genetics

E. R. KERBER, B.S.A., M.Sc., Ph.D.

Wheat cytogenetics

D. LEISLE, B.S.A., M.Sc., Ph.D.

Durum wheat breeding

D. R. METCALFE, B.S.A., M.Sc., Ph.D.

Barley breeding and genetics

R. I. H. MCKENZIE, B.S.A., M.Sc., Ph.D.

Oat breeding and genetics

Cereal Diseases Section

R. ROHRINGER, Dr. sc. agr.

Head of Section; Molecular
biology of cereal rust

A. W. CHIKO, B.Sc., M.Sc., Ph.D.

Viruses

C. C. GILL, B.Sc., Ph.D.

Viruses

G. J. GREEN, B.S.A., M.Sc., Ph.D.

Wheat stem rust

D. E. HARDER, B.Sc., M.Sc., Ph.D.

Oat crown rust

W. K. KIM,¹ B.Sc., M.Sc., Ph.D.

Molecular biology of cereal rust

J. W. MARTENS, B.Sc., Ph.D.

Oat stem rust

J. T. MILLS, B.Sc., Ph.D., D.I.C., F.L.S.

Ecology of soil fungi; fungicides

J. J. NIELSEN, Dr. sc. agr.

Smuts

D. J. SAMBORSKI, B.S.A., M.Sc., Ph.D.

Wheat leaf rust

A. TEKAUZ, B.Sc., M.Sc., Ph.D.
P. L. THOMAS, B.S.A., M.Sc., Ph.D.

Leaf diseases
Microbial genetics, smuts

Cereal Crop Protection Section

F. L. WATTERS, B.Sc., M.Sc., Ph.D.
P. S. BARKER, I.A., M.Sc., Ph.D.
B. BERCK, B.S.A., M.Sc., F.C.I.C.
M. BICKIS, B.Sc.
S. R. LOSCHIAVO, B.Sc., M.Sc., Ph.D.
W. ROMANOW, B.S.A., M.Sc.
R. N. SINHA, B.Sc., Ph.D.

L. B. SMITH, B.Sc., M.Sc., Ph.D.
P. H. WESTDAL, B.Sc., M.Sc., Ph.D.

Head of Section; Storage pest control
Biology and control of stored grain pests
Fumigant chemistry
Biometrics
Stored grain insect biology
Insect surveys and control
Ecology of granary insects, mites, and fungi
Population dynamics
Biology and control of field crop insects

Integrated Pest Control Section

W. J. TURNOCK, B.S.A., M.Sc., Ph.D.

G. L. AYRE, B.S.A., M.Sc.
R. P. BODNARYK, B.A., M.Sc., Ph.D.
G. K. BRACKEN, B.Sc., M.Sc., Ph.D.
G. E. BUCHER, B.A., M.A., Ph.D.
G. H. GERBER, B.S.A., Ph.D.
B. M. HEGDEKAR, B.Sc., M.Sc., Ph.D.
C. E. OSGOOD, B.Sc., M.Sc., Ph.D.
H. G. WYLIE, B.A., Ph.D.

Head of Section; Ecology and population dynamics
Insect ecology
Nutritional physiology
Physiology and behavior
Insect pathology
Reproductive physiology
Reproductive biochemistry
Behavior and fecundity
Host-parasite relations

Departures

W. R. ALLEN, B.Sc., M.Sc., Ph.D.
Died June 10, 1973
W. A. F. HAGBORG, B.S.A., Ph.D.
Retired March 30, 1973
J. VANDERLEE, R.I.A.
Resigned December 1973

Toxicology

Bacterial diseases; antibiotics

Administrative Officer

VISITING SCIENTISTS

National Research Council postdoctorate fellows

A. CAMPBELL, B.Sc., M.Sc., Ph.D.	Entomology
N. K. HOWES, B.Sc., Ph.D.	Physiology of parasitism

Graduate students

P. A. BURNETT, B.Ag.Sci., M.Ag.Sci.	Entomology
F. A. KIEHN, B.S.A.	Plant breeding
M. O. OSORO, M.Sc.	Plant pathology
P. L. SHOLBERG, B.Sc.	Microbiology
S. TAUTHONG, B.Sc.	Entomology

¹On transfer of work to the Nagoya University, Chikusa, Nagoya, Japan, September 1973 to August 1974.

INTRODUCTION

A new program to develop a pest management system to control insects on rapeseed was begun. Good progress was made in developing standard techniques for sampling, after monitoring, and in collecting data on damage assessment and pest survival that will be useful in constructing a model.

A specific RNA fraction was isolated from wheat that confers the same type of temperature-sensitive resistance to stem rust as the gene *Sr6*. This discovery could lead to the identification of the biochemical basis for disease resistance in plants.

Hudson, a new cultivar of oats, was licensed. It is more resistant to rust, smut, and lodging than currently grown cultivars, and performs well under conditions of high fertility.

Dr. W. A. F. Hagborg retired after a long career in agricultural research. Although bacteriology was his main field of interest, he also made valuable contributions in the areas of plant virology and chemical control of rusts.

Dr. W. R. Allen died suddenly on June 10, 1973. His knowledge and experience in field crop entomology and toxicology were respected by his colleagues.

Further information on the research summarized in this report can be obtained from Research Station, Research Branch, Agriculture Canada, 25 Dafoe Road, Winnipeg, Man. R3T 2M9.

W. C. McDonald
Director

BREEDING, GENETICS, AND CYTOGENETICS

Common Wheat

In a study of postharvest dormancy, 80 F_4 lines of Neepawa⁶ × RL 4137 were grown and tested. Of these, 39 appeared highly dormant and were harvested. A weathering-resistance characteristic, which results in better retention of the red kernel color and presumably also in better test weight, was associated with dormancy, but not completely linked. Incorporation of both these characteristics into commercial cultivars could benefit farmers considerably through the higher grades received for their grain.

The inheritance of virulence on the *Lr2* alleles for resistance to leaf rust was studied by the use of various populations of selfed, "backcross" selfed, and F_1 and F_2 cultures involving races 9, 11, and 161. The *Lr2* alleles from Webster, Carina, Brevit, and Loros were transferred into Thatcher, Red Bobs, and Prelude. Race 11, and probably race 161, have a single recessive gene, *p2*, for virulence on the three *Lr2* alleles and an additional gene(s) that modifies or inhibits the action of the *p2* gene on the three host alleles. Lines with the *Lr2a* allele were the most resistant to the most cultures, those with *Lr2b* were intermediate, and those with *Lr2c* were the least resistant. The *Lr2* alleles were

most effective when in Thatcher, intermediate in Prelude, and least in Red Bobs.

Three ditelosomic stocks of the bread wheat cultivar Canthatch were tested to determine the effect of the absence of an arm of chromosomes 4D, 5D, and 7D on specific milling and baking properties. Ditelo-4D was inferior to Canthatch in mixogram rating (gluten properties), sedimentation, and loaf volume; ditelo-7D was similar to Canthatch in most respects; and ditelo-5D was superior to Canthatch in mixogram rating, farinograph absorption, and loaf volume.

Biometrical genetic studies of F_7 random lines in two wheat crosses corroborated previous findings on the relative heritabilities of yield, maturity, kernel weight, sedimentation, protein content, and mixograph measurements. Sedimentation value, grinding time, and protein content proved to be the best predictors of farinograph absorption and remix loaf volume. In some cases, quality characteristics were found to be correlated with head type, spike density, waxiness, or rust resistance.

A study on the combining ability of four synthetic hexaploids that differed only in their D genomes suggested that hybrid vigor for flowering time, yield, and components of yield was due to the general luxuriance of the hybrids, rather than to nonadditive gene action.

Durum Wheat

Research was continued on postharvest dormancy, ergot resistance, genetics of loose smut resistance, and incorporation of additional stem and leaf rust resistance into advanced lines. Efforts to develop acceptable semidwarf cultivars continue to be hampered by problems of kernel shriveling and starchiness. Italian short-strawed mutants are being evaluated as alternative parental material.

The inheritance of leaf pubescence was studied in the F_1 , F_2 , and backcross- F_1 populations of crosses between PI 181000 (*Triticum turgidum* L.) and two glabrous durum cultivars. Leaf pubescence confers resistance to the cereal leaf beetle. Examination of density of pubescence in the F_1 indicated that the density level of the pubescent parent is dominant. Data for presence or absence of pubescence in segregating populations indicated that three genes control the presence of pubescence in PI 181000. It is postulated that these same genes may be operating in an additive manner to determine length of pubescence. The rather simple inheritance of this character indicates that a backcross program can be used to transfer pubescence to commercial cultivars.

Barley Breeding

The defects in kernel type and threshability of the lines of two-rowed barley, developed with genes for resistance to net blotch and stem rust combined with those conditioning improvements in agronomic type, were corrected. Several lines showing superiority in yield over commercially grown cultivars will be advanced to regional yield trials in 1974. Progress was also made in transferring the fast modifying enzyme system and disease resistance features from stocks developed earlier in the program to lines possessing more acceptable agronomic characteristics and higher yield. The multiple embryo defect of earlier-developed lines also has been eliminated. The "Jet" smut resistance system has been transferred to disease-resistant and agronomically acceptable lines of two-rowed barley and these will now be crossed to the cultivar Valkie to overcome the new smut races becoming prevalent on the prairies.

In the six-rowed barley breeding program progress continued toward the goals of combining high yield, high test weight, quality, and disease resistance plus good

agronomic characters. Additional work is under way to incorporate high amylose, high lysine, plumper kernels, resistance to barley stripe mosaic virus, and improved smut resistance into parental lines.

Oat Breeding

Hudson, a new rust-resistant and strong-strawed oat cultivar, was licensed in 1973. It was developed from the complex cross ((CI 6792 – Rodney \times OT 174) \times RL 2877) \times (Pendek \times Lodi). The straw strength of this cultivar should result in its responding well to good management. Hudson has moderate to good resistance to the stem rust races prevailing in Western Canada because of its combination of resistance genes *Pg2*, *Pg4*, and *Pg9*. It also has moderate resistance to crown rust, and resistance to the older races of smut, but not to the newer ones now appearing in Western Canada.

In cooperative studies with the Animal Science Department, University of Manitoba, the feeding value of CI 4492, a high-fat oat, and of Garry, a low-fat oat, were compared. Feed efficiencies from the high-fat oats were much superior to Garry and at least equal to barley for finishing hogs and for feeder cattle.

CEREAL RUSTS

Stem Rust of Wheat

The dramatic decline in the prevalence of wheat stem rust in Western Canada, and presumably central North America, in recent years can be attributed to the widespread cultivation of resistant cultivars. New pathogenic strains will have to evolve for the rust to regain its prevalence, but there is no evidence that this has happened. Most new strains are in the old race 11-32-113 group or in the race 15B group. They have either added virulence or lost virulence on a single resistance gene. Most concern centers on several new strains in the 11-32-113 group (C20, C22, C35, C41, C51, and C52) that have some virulence on the cultivars Selkirk, Manitou, Neepawa, and Pitic 62. These strains lack aggressiveness, but the evolution of greater aggressiveness in this group could produce potentially destructive races. To offset this possibility, resistance gene *Sr11* and a new kind of resistance from the line CI 8154 \times Frocor² are being added to Neepawa.

Leaf Rust of Wheat

Leaf rust of wheat was first found in southern Manitoba on June 14 and was widespread in Manitoba and eastern Saskatchewan by the middle of July. Moderate to severe infections were present on Manitou and Neepawa in early August east of a line running through Yorkton and Estevan. The amount of leaf rust diminished west of this line and damage to wheat was restricted to the heavily infected eastern area. It was estimated from field observations that leaf rust caused yield losses of 5 to 10% in this area. New strains of leaf rust in the population, resulting in increased virulence on Manitou and Neepawa, are chiefly responsible for this high incidence of leaf rust. It is almost certain that this area will suffer comparable losses in most years until new resistant cultivars are available. The utility wheat, Glenlea, is at present highly resistant in the field.

Stem Rust of Oats

Hexaploid lines of oats collected in North Africa in 1972 were evaluated and a large pool of what could be new resistance genes mostly for crown rust but also for stem rust was discovered. The stem rust resistance from Tunisia, Algeria, and Morocco represents a big advance in the quest for an adequate resistance pool. Characterization and genetic studies are under way in cooperation with the plant breeders.

Crown Rust of Oats

The 1973 survey of races of oat crown rust disclosed some changes in the number and distribution of races. Race 295 still predominated, but several other races have increased significantly, the most notable being races 210, 284, and 330. Race 284 is new to Manitoba, and several isolates of this race are virulent on the cultivar Hudson.

Molecular Biology of Rust Resistance

Products of the gene-for-gene interaction between host and parasite were studied in two near-isogenic lines of wheat (cultivar Chinese Spring resistant and Chinese Spring susceptible at the *Sr6* locus for resistance) and two strains of wheat stem rust, race 56, one avirulent and one virulent against the *Sr6* gene. High-temperature breakdown (above 25°C) of the *Sr6* gene for resistance was used to obtain genotypically resistant

leaves extensively colonized with avirulent and virulent strains of the fungus. Seventy-two hours after inoculation, the plants were transferred to 20°C for a further 30 h to induce the necrotic reaction. Various extracts were prepared from infected tissues that were temperature-treated in this way. A nucleic acid fraction was obtained by extraction with chloroform – phenol – aqueous K_2HPO_4 , and purified by precipitation with cetyltrimethylammonium bromide. The extracts were assayed by injection into test leaves, which were subsequently examined histologically for necrotic cells. The nucleic acid fraction from genotypically resistant leaves infected with the avirulent strain caused necrosis when injected into leaves infected with the virulent strain, but was inactive if incubated with ribonuclease prior to injection. It was also inactive when injected prior to haustorial formation, and when injected into noninfected leaves. A similar fraction from resistant leaves infected with the virulent strain did not cause necrosis when tested in this bioassay system.

OTHER CEREAL DISEASES

Smuts

Three collections of loose smut of barley (*Ustilago nuda* (Jens.) Rostr.) from Manitoba and Saskatchewan were virulent on commercial cultivars derived from Jet (CI 967): Bonanza (CI 14003), Conquest (CI 11638), Keystone (CI 10877), and Paragon (CI 13649). These cultivars were previously resistant to all races in North America. The virulence pattern of one of the cultures indicates that the genes *Un* and *Un8* confer resistance and that the genes *Un* and *Un3* are independent.

Virulence of *Ustilago hordei* (Pers.) Lagerh. and *U. nigra* Tapke on the barley cultivars Keystone and Conquest was studied. One recessive gene, the same in both species, appeared to confer virulence on both cultivars. Earlier investigators had found identical virulence genes in both species of smut for the cultivars Excelsior, Lion, Pannier, and Trebi. Therefore, testing for resistance or susceptibility in a breeding program could be done with a strain of only one of the species.

Auxotrophic mutants of *U. hordei* were recovered after UV irradiation of a wild-type

culture, inositol starvation of an inositol-requiring culture, and a combination of the two methods. Of the survivors of UV irradiation followed by inositol starvation, 1.9% were found to carry a requirement additional to inositol. Inositol starvation by itself gave only 0.27% recovery, and UV irradiation alone was even less efficient.

Spores of *Ustilago tritici* (Pers.) Rostr. were germinated on a medium containing benzoic acid, which induces the formation of dikaryons and inhibits mitosis. After removal of benzoic acid from the medium, mitosis occurred and the four monokaryotic haplonts formed by one spore were isolated by microsurgery. Both mating types grow readily on a minimal medium, in contrast with *U. nuda*, whose mating type *a* is proline-deficient. This fundamental physiological difference, supported by previously known morphological differences, was used as evidence to retain *U. tritici* (loose smut of wheat) and *U. nuda* (loose smut of barley) as separate species.

Twenty-seven lines of triticale (*Triticale hexaploide* Lart.) were inoculated with a mixture of races T1 to T5 of loose smut of wheat; six lines were susceptible, the level of infection ranging up to 67%. The race virulent on three of the lines was found to be T4, a race characterized by virulence on cultivars of durum wheat (*Triticum turgidum* L.). Of 119 cultivars of spring rye (*Secale cereale* L.) that were inoculated with the mixture of races, 68 were infected.

Blue Dwarf of Oats

In greenhouse experiments, the yield of oats infected with oat blue dwarf virus at the two-leaf stage was reduced by 48%. There were fewer seeds produced on both the main culm and tillers of infected plants than on healthy plants and there were fewer seed-bearing tillers. Kernel weight was not affected. Infected plants were shorter than healthy plants and heading was delayed by 11 days. Plants exposed to nonviruliferous leafhoppers were shorter than healthy plants and heading was delayed by 4.5 days. In addition, the number of headed tillers and seeds was reduced to about the same extent as that of plants exposed to viruliferous leafhoppers. However, due to increased kernel weight, total seed yield, although lower, was not significantly different from that of the control plants.

Barley Stripe Mosaic

A study of symptomless infection by barley stripe mosaic virus (BSMV) in fields of two-rowed barley was concluded. Symptomless, infected plants were only detected adjacent or very close to plants with BSM symptoms. Therefore, most symptomless infections were probably due to contact transmission of the virus late in the growing season. In fields (late tillering to boot stage) with diseased plants scattered rather uniformly throughout, the proportion of plants infected with BSMV was about 1½ to 2 times the proportion of plants with symptoms.

A comparison between the yield of plants with BSM symptoms and the yield of apparently healthy plants in a commercial field of two-rowed barley showed that the average yield of diseased plants was 36% less than that of healthy plants. The yield loss was attributable to reductions in kernel weight, number of heads per plant, and number of seeds per head.

The progeny of 30 single plant selections of Moreval barley were evaluated for heterogeneity of reaction to each of four isolates of BSMV. Three isolates either failed to infect plants of any of these selections or infected only a small proportion of plants of a few selections. One isolate infected each selection, the proportion of infected plants varying from 15 to 93%. Further testing of selections yielding these extremes indicated that differences in the proportion of plants infected with the latter isolate was due to random variation in the inoculation technique rather than genetic variability of the host.

Wild oats growing in a field of two-rowed barley were found to be infected with BSMV. This species is apparently only the third host, besides wheat and barley, in which the virus has been detected in nature. In this particular situation, it appeared that BSMV was transmitted to the wild oats from barley because a much higher proportion of barley plants were infected.

STORED PRODUCTS ENTOMOLOGY

Surveys

A survey of farm-stored grain in Manitoba was conducted during the summer of 1973 to determine the incidence of insect infestations

and to compare the effectiveness of grain probes and an improved trapping device developed at this station. Of 188 farms visited, 128 were infested with fungus beetles, or rusty grain beetles, or both. The effectiveness of traps in detecting insects was 97%, and of grain probes, 59%.

Biology

Studies on the dispersal of the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), indicated that adults move readily not only to all parts of a grain bulk within a granary, but also to other granaries and even to other farms. The adults fly extensively from the end of July until the end of September at times when the surface temperature of the grain mass is above 20°C. Flight occurs mainly in the late afternoon. Piles of grain residues appear to be important reservoirs of rusty grain beetles and other stored-grain pests.

The extracts from the fat-soluble components of raw wheat germ were assayed for aggregant or arrestant activity with adults of the confused flour beetle, *Tribolium confusum* Jacquelin duVal. Some extracts elicited a strong response, others had little effect, and still others were repellent. The concentration of peroxide in the ether was shown to be inversely correlated with the aggregating response evoked by the extract. In the preparation of extracts of biological material, therefore, solvents other than ether should be used unless the peroxide component is completely eliminated immediately before use.

Triglycerides of *Nigrospora sphaerica* (Sacc.) Mason, which cause adult confused flour beetles to aggregate, were separated according to their degree of unsaturation by chromatographic methods. Several fractions showed activity. The largest and most active fraction consisted of monounsaturated triglycerides, of which the major component was oleodipalmitin. Triglycerides from three other fungi showed varied levels of activity.

Ecology

The grocer's itch mite, *Glycyphagus domesticus* (De Geer), and the grain mite, *Acarus siro* L., were exposed at $17 \pm 1^\circ\text{C}$ and $75 \pm 2\%$ relative humidity to 19 species (17 genera) of fungi and 6 species (5 genera) of bacteria. The rusty grain beetle and the foreign grain beetle, *Ahasverus advena* (Waltl), were exposed to bacteria only. Both

mites thrived on *Syncephalastrum racemosum* Cohn ex Schroet., *Absidia spinosa* Lendner, and *Curvularia geniculata* (Tracy & Earle) Boedijn, but failed to survive and multiply on *Aspergillus ochraceus* Wilhelm, *Gliocladium roseum* Bain, or *Penicillium* sp. *G. domesticus* multiplied 30 times on *S. racemosum*, whereas *A. siro* multiplied 40 times on *A. spinosa*. Neither of the two mites fed adequately or multiplied on any bacterial species. All mites died in about 35 days and 50% died in 5 days. It was concluded that bacteria, unlike fungi, adversely affect both mite and insect pests of stored products.

Control

The persistence of deposits of malathion, iodophos, bromophos, and pyrethrins - piperonyl butoxide applied as water emulsions on wood surfaces was assessed at 1, 4, 8, and 16 wk after treatment. The surfaces were bioassayed with adults of the red flour beetle, *Tribolium castaneum* (Herbst); the confused flour beetle; the sawtoothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus); the merchant grain beetle, *O. mercator* (Fauvel); and the rusty grain beetle. After 16 wk, malathion, iodophos, and bromophos, each applied at 0.495 g/m², provided complete control of all species exposed on surfaces for 24 h. Pyrethrins (P) + piperonyl butoxide (PB) at 0.02 g P + 0.2 g PB/m² were ineffective against the confused flour beetle and the red flour beetle at 1 wk after treatment, but 0.004 g P + 0.041 g PB/m² persisted for 16 wk against the sawtoothed grain beetle, the merchant grain beetle, and the rusty grain beetle.

Field trials were carried out to compare the effectiveness of malathion and bromophos applied to the floors and walls of farm granaries. Emulsifiable concentrates of each insecticide were diluted with water to provide an emulsion containing 2% of actual insecticide, which was applied with a pressurized tank sprayer at 0.05 litre/m² (1 Imp gal/1,000 ft²). The treatments were assessed by bioassay with rusty grain beetle adults placed on the floors of each granary. Of the 15 granaries selected for treatment, 7 were excluded because of toxic floor residues from previous treatments. Malathion provided complete control of test insects placed on wood floors, but inadequate control on concrete floors. Bromophos was effective on both wood and concrete floors. The results

confirm previous laboratory work, showing that malathion breaks down rapidly on alkaline concrete surfaces.

FIELD CROP INSECTS

Insecticides

Seven insecticides were applied at various rates by three methods to control the sugarbeet root maggot, *Tetanops myopaeformis* (Roeder). Granular applications of carbofuran and Counter (Cyanamid of Canada) at 1,121 g/ha (16 oz/ac) and aldicarb at 560.5 g/ha (8 oz/ac) to the seed furrow were not phytotoxic, controlled maggot damage, and increased yields.

Sprays of leptophos and chlorpyrifos at 560.5 g/ha (8 oz/ac) gave 100 and 94% control of the redbacked cutworm on sugar beets within 96 h of application.

Grasshopper Surveys

The forecast of grasshopper infestations in Manitoba in 1974 showed a very slight increase in the degree of severity and an increase of about 10% in area infested compared with that of the forecast for 1973. Of the 14,343 km² (5,538 sq miles) rated as infested with grasshoppers, 9,098 km² (3,513 sq miles) were rated light, 4,115 km² (1,589 sq miles) moderate, and 1,129 km² (436 sq miles) severe. The largest and most heavily infested areas include the entire Red River Valley, an area extending north to Gladstone and Neepawa, and an area southwest from Neepawa to Douglas.

INTEGRATED CONTROL OF INSECT PESTS

A comprehensive program employing an integrated approach to the control of insects attacking rapeseed was started in 1973. The objectives of this program are: (i) to protect the rapeseed crop from the attack of insect pests in a manner that will maximize cost-benefit relationships and minimize environmental degradation; (ii) to develop practical alternatives to extensive use of broad-spectrum chemical insecticides for crop protection; and (iii) to develop methods for preventing insect attack, by exploring all principles, tactics, and strategies through a pest management system that maximizes cost-benefit relationships on a regional basis.

Emphasis will be placed first on research in the areas designated below.

Sampling Techniques

Several methods of estimating population numbers of the bertha armyworm, *Mamestra configurata* Wlk., and flea beetles, *Phyllotreta* spp., and of monitoring their changes were evaluated statistically to develop a standard sampling technique.

Damage Assessment

A method for determining the relationship between larval density and plant damage was tested by caging fourth-instar larvae of the bertha armyworm (laboratory reared) at different densities in an open rapeseed field in the Neepawa area. The number of damaged pods ranged from 0.8/plant in control cages to 5.0/plant at the highest density (50 larvae/cage). The number of pupae retrieved was 50% or less of the original number of larvae introduced.

Studies to determine the effects of known population numbers of flea beetles on rapeseed yields indicated that treatment of three beetles/plant produced 57% leaf loss compared with 25% for one beetle/plant and 10% for controls. Plants in treatments of three beetles/plant flowered later and were shorter at maturity than those in other treatments.

Biology

Several studies on techniques for rearing large numbers of the bertha armyworm in the laboratory were made as a prerequisite to research on its biology.

Performance norms were established on spring-collected pupae with naturally broken diapause to serve as a basis for comparing diet-reared with natural insects. Modal figures are: pupal weight 350 mg; adult emergence 95%; mating 95%; and productivity 1,100 eggs per mated female, with 55% mated females failing to lay fertile eggs.

Methods of rearing on leaves are incapable of providing sufficient insects for an experimental program. A small number of larvae were hand-reared on leaves to determine food consumption in relation to development. Larvae eat about twice their weight in leaves per day and convert into body weight from 40% of this in the first instar to 15% in the sixth instar. A larva consumes about 4,350 mg, or 220 cm², of rapeseed leaf,

about 95% of which is eaten during a 6–7 day peak feeding period.

Four generations of the bertha armyworm have been reared continuously on 27 variations of an artificial diet. Ascorbic acid and possibly other vitamins are essential to prevent pupal malformation or “syndrome.” Best diets produce 70–90% living pupae, of which 50–55% show no syndrome. Adult performance is equal to that of field-collected insects.

An analysis of certain cryoprotective agents showed that pupae are capable of supercooling down to -20°C . Biochemical methods have been established for distinguishing between diapausing and nondiapausing pupae by means of oxygen consumption studies and certain carbohydrate contents. Diapause in this insect depends on both rearing temperature and photoperiod; a 14-h photoperiod and 21°C temperature appear to be ideal for diapause induction. Higher temperature or longer photoperiod tends to produce nondiapausing pupae.

Three hitherto unknown catecholamines were isolated from the armyworm, *Spodoptera*, and the cockroach, *Periplaneta*, identified by physical and chemical techniques,

and finally synthesized. Their biochemical role during the insect’s molting process was established by radioisotope experiments. The substituted catecholamines represent a new and unsuspected class of compounds in Insecta.

Parasites

One ichneumonid, *Banchus* sp., and two tachinids, *Athrycia cinerea* (Coq.) and *Mericia ampelus* (Wlk.), were identified and confirmed as parasites of the bertha armyworm in Manitoba. Procedures for overwintering *A. cinerea* and *M. ampelus* and for propagating all three species of parasites were developed. Seasonal history, distribution, and the main features of its biology were determined for each parasite. Tests showed that *Banchus* sp. superparasitizes and kills not only the full-grown bertha armyworms on which it matures, but also many immature individuals before they have damaged rapeseed plants significantly. Twenty-six other parasitic species associated with the bertha armyworm or with other lepidopterous pests of rapeseed were collected or reared.

PUBLICATIONS

Research

- Baker, R. J. 1973. Assortative mating and artificial selection. *Heredity* 31:231-238.
- Barker, P. S., and Vaisey, M. 1973. Effect of storage condition and time on the odor of malathion-treated wheat. *J. Stored Prod. Res.* 9:171-180.
- Bodnaryk, R. P., and McGirr, L. 1973. Purification, properties and function of a unique γ -glutamyl cyclotransferase from the housefly, *Musca domestica* L. *Biochim. Biophys. Acta* 315:352-362.
- Bronswijk, J. E. M. H. van, and Sinha, R. N. 1973. Role of fungi in the survival of *Dermatophagoides* (Acarina: Pyroglyphidae) in house-dust environment. *Environ. Entomol.* 2:142-145.
- Bucher, G. E. 1973. Definition and identification of insect pathogens. *Ann. N.Y. Acad. Sci.* 271:8-17.
- Cheng, H. H., and Bucher, G. E. 1973. Field comparison of the Neoaplectanid nematode DD136 with diazinon for control of *Hylemya* spp. on tobacco. *J. Econ. Entomol.* 65:1761-1763.
- Chiko, A. W. 1973. Barley stripe mosaic in the Canadian prairies in 1972. *Can. Plant Dis. Surv.* 53:107-111.
- Chiko, A. W. 1973. Failure to transmit barley stripe mosaic virus by aphids, leafhoppers, and grasshoppers. *Plant Dis. Rep.* 57:639-641.
- Dolinski, M. G., and Loschiavo, S. R. 1973. The effect of fungi and moisture on the locomotory behavior of the rusty grain beetle, *Cryptolestes ferrugineus* (Coleoptera: Cucujidae). *Can. Entomol.* 105:485-490.
- Dondale, C. D., and Hegdekar, B. M. 1973. The contact sex pheromone of *Pardosa lepidicina* Emerton (Araneida: Lycosidae). *Can. J. Zool.* 51:400-401.

- Gerber, G. H. 1973. Reproductive behavior and physiology of *Tenebrio molitor* (Coleoptera: Tenebrionidae). I. Initiation of mating in young adults and the effects of adult density. *Can. Entomol.* 105:807-811.
- Gerber, G. H., and Church, N. S. 1973. Courtship and copulation in *Lyttia nuttalli* Say (Coleoptera: Meloidae). *Can. Entomol.* 105:719-724.
- Green, G. J. 1973. Air-borne rust inoculum over Western Canada in 1972. *Can. Plant Dis. Surv.* 52:160-161.
- Green, G. J. 1973. Stem rust of wheat, barley and rye in Canada in 1972. *Can. Plant Dis. Surv.* 52:162-167.
- Hagborg, W. A. F., Chiko, A. W., Fleischmann, G., Gill, C. C., Green, G. J., Martens, J. W., Nielsen, J. J., and Samborski, D. J. 1972. Losses from cereal diseases in Manitoba in 1971. *Can. Plant Dis. Surv.* 52:113-118.
- Hagborg, W. A. F. 1973. Gray speck of oats in Western Canada. *Can. Plant Dis. Surv.* 53:72-78.
- Haggag, M. E. A., and Dyck, P. L. 1973. The inheritance of leaf rust resistance in four common wheat varieties possessing genes at or near the *Lr3* locus. *Can. J. Genet. & Cytol.* 15:127-134.
- Haggag, M. E. A., Samborski, D. J., and Dyck, P. L. 1973. Genetics of pathogenicity in three races of leaf rust on four wheat varieties. *Can. J. Genet. & Cytol.* 15:73-82.
- Harder, D. E., and Harris, D. C. 1973. Halo blight of oats in Kenya. *East Afr. Agric. For. J.* 38:241-245.
- Hegdekar, B. M., and Arthur, A. P. 1973. Host hemolymph chemicals that induce oviposition in the parasite *Itopectis conquisitor* (Hymenoptera: Ichneumonidae). *Can. Entomol.* 105:787-793.
- Kerber, E. R., and Dyck, P. L. 1973. Inheritance of stem rust resistance transferred from diploid wheat (*Triticum monococcum*) to tetraploid and hexaploid wheat and chromosome location of the gene involved. *Can. J. Genet. & Cytol.* 15:397-409.
- Loschiavo, S. R., and Atkinson, J. M. 1973. An improved trap to detect beetles (Coleoptera) in stored grain. *Can. Entomol.* 105:437-440.
- Martens, J. W. 1973. Competitive ability of oat stem rust races in mixtures. *Can. J. Bot.* 51:2233-2236.
- Martens, J. W. 1973. Stem rust of oats in Canada in 1972. *Can. Plant Dis. Surv.* 52:171-172.
- Martens, J. W., Fleischmann, G., and McKenzie, R. I. H. 1973. Effects of natural infections of crown rust and stem rust on yield and quality of oats in Manitoba. *Can. Plant Dis. Surv.* 52:122-125.
- Martens, J. W., and McKenzie, R. I. H. 1973. Resistance and virulence in the Avena: *Puccinia coronata* host-parasite system in Kenya and Ethiopia. *Can. J. Bot.* 51:711-714.
- Maw, M. G., and Bracken, G. K. 1972. The use of artificial pools in assessing populations of the mosquito *Culex restuans* Theobald. *Proc. Entomol. Soc. Ont.* 102:78-83.
- McGinnis, A. J., and Loschiavo, S. R. 1973. Repellency of wheat germ extracts prepared with peroxide-containing ether to adults of *Tribolium confusum* (Coleoptera: Tenebrionidae). *Can. Entomol.* 105:133-137.
- Mills, J. T. 1972. Cooperative seed treatment trials—1972. *Can. Plant Dis. Surv.* 53:126-129.
- Mills, J. T. 1972. Interactions among biotic variables affecting *Cochliobolus sativus* as a pathogen of cereals. *Can. Plant Dis. Surv.* 52:130-136.
- Mills, J. T., and Alley, B. P. 1973. Interactions between biotic components in soils and their modification by management practices in Canada: A review. *Can. J. Plant Sci.* 53:425-441.
- Mills, J. T., and Silversides, W. H. 1973. Effect of 2-(thiocyanomethylthio) benzothiazole (TCMTB) on emergence and germination of cereals, flax, and rape. *Can. Plant Dis. Surv.* 53:5-10.
- Muir, W. E., Sinha, R. N., and Wallace, H. A. H. 1973. Abiotic and biotic characteristics of grain stored in temporary farm bins. *Can. Agric. Eng.* 15:35-42.
- Nielsen, J. 1973. Reaction of triticale and spring rye to loose smut of wheat. *Can. J. Plant Sci.* 53:749-753.
- Quinones, M. A., Larter, E. N., and Samborski, D. J. 1972. The inheritance of resistance to *Puccinia recondita* Rob. ex Desm. in hexaploid triticale. *Can. J. Genet. & Cytol.* 14:495-505.
- Redshaw, E. S., Hougen, F. W., and Baker, R. J. 1970. A distillation technique for isolation of volatile material for gas chromatographic analysis and its application to coriander seed (*Coriandrum sativum*). *J. Agric. & Food Chem.* 19:1264-1266.
- Samborski, D. J. 1973. Leaf rust of wheat in Canada in 1972. *Can. Plant Dis. Surv.* 52:168-170.

- Samborski, D. J., and McKenzie, R. I. H. 1973. Crown rust of oats in Canada in 1972. *Can. Plant Dis. Surv.* 52:173-174.
- Sinha, R. N. 1972. Interrelations of physical, chemical and biological variables in the deterioration of stored grains. Pages 15-47 in R. N. Sinha and W. E. Muir, eds. *Grain storage—part of a system*. The Avi Publishing Co., Westport, Conn.
- Sinha, R. N., and Wallace, H. A. H. 1973. Population dynamics of stored-product mites. *Oecologia (Berl.)* 12:315-327.
- Sinha, R. N., Yaciuk, G., and Muir, W. E. 1973. Climate in relation to deterioration of stored grain. A multivariate study. *Oecologia (Berl.)* 12:69-88.
- Smith, B. C., Starratt, A. N., and Bodnaryk, R. P. 1973. Oviposition responses of *Coleomegilla maculata lengi* (Coleoptera: Coccinellidae) to the wood and extracts of *Juniperus virginiana* and to various chemicals. *Ann. Entomol. Soc. Am.* 66:452-456.
- Thomas, P. L. 1973. Increased frequency of auxotrophic mutants of *Ustilago hordei* after combined UV irradiation and inositol starvation. *Can. J. Genet. & Cytol.* 14:785-788.
- Turnock, W. J. 1973. Factors influencing the fall emergence of *Bessa harveyi* (Townsend) (Tachinidae: Diptera) in Manitoba. *Can. Entomol.* 105:399-409.
- Wallace, H. A. H. 1972. Fungi and other organisms associated with stored grain. Pages 71-98 in R. N. Sinha and W. E. Muir, eds. *Grain storage—part of a system*. The Avi Publishing Co., Westport, Conn.
- Westdal, P. H., and Romanow, W. 1973. Observations on the biology of the flea beetle, *Phyllotreta cruciferae* (Coleoptera: Chrysomelidae). *Manit. Entomol.* 6:35-45.
- Wylie, H. G. 1973. Control of egg fertilization by *Nasonia vitripennis* (Hymenoptera: Pteromalidae) when laying on parasitized house fly pupae. *Can. Entomol.* 105:709-718.
- Wylie, H. G. 1973. Parasites of face fly, *Musca autumnalis* (Diptera: Muscidae), and associated Diptera near Belleville, Ontario. *Can. Entomol.* 105:257-261.

Miscellaneous

- Berck, B. 1973. Canada's North. *Agrologist* 2(5):3-5.
- Berck, B. 1973. Cold storage at Churchill? *Canadex* 732.
- Bucher, G. E. 1973. Control of tobacco pests with pathogens in Ontario. Paper presented at the Fifth Int. Colloquium on Insect Pathology and Microbial Control. Oxford.
- Chiko, A. W. 1973. Barley stripe mosaic. *Can. Agric.* 18(4):26-28.
- Green, G. J. 1973. Wheat stem rust in Western Canada. *Canadex* 112.632.
- McKenzie, R. I. H., and Martens, J. W. 1973. Breeding for stem rust resistance in oats. Paper presented at the Conf. on Induced mutations for disease resistance in crop plants. Int. At. Energy Agency, Novi Sad, Yugoslavia.
- Mills, J. T., and Nielsen, J. J. 1973. Seed treatment update '73. *Can. Agric.* 18(2):6-7.
- Samborski, D. J. 1973. Wheat leaf rust in Western Canada. *Canadex* 112.632.
- Sinha, R. N. 1973. A look at grain storage problems. *Can. Agric.* 18(1):33-35.
- Smith, L. B., and Robertson, J. T. 1973. Stored grain insect trap. *Canadex* 110.60.

Research Station Melfort, Saskatchewan

PROFESSIONAL STAFF

S. E. BEACOM, B.Sc., M.S., Ph.D.

Director

Forage Production and Utilization

D. A. COOKE, B.S.A., M.Sc.

Program Leader: Breeding,
evaluation, and production

W. E. COATES, B.Sc., M.Sc., Ph.D.

Forage harvesting systems

D. H. MCCARTNEY, B.Sc., M.Sc.

Beef cow management systems

J. A. ROBERTSON, B.Sc., M.Sc., Ph.D.

Forage utilization (beef cattle)

S. O. THORLACIUS, B.Sc., M.Sc., Ph.D.

Forage evaluation (sheep)

J. WADDINGTON, B.Sc., M.Sc., Ph.D.

Ecology and weed control

Cereal and Oilseed Production and Utilization

K. E. BOWREN, B.S.A.

Program Leader: Tillage and
cropping

A. G. CASTELL, B.Sc., M.Sc., Ph.D.

Crop utilization (swine)

W. F. NUTTALL, B.S.A., M.Sc., Ph.D.

Soil fertility

K. W. PLEWS, B.Sc., M.Sc.

Cereal, oilseed, and special crop
evaluation

INTRODUCTION

Our research program in 1973 was strengthened by the appointment of Dr. W. E. Coates, an agricultural engineer, to work on the development of forage and cereal harvesting systems; Mr. K. W. Plews, a cereal biologist, to continue the work on cereal, oilseed, and special crop evaluation; and Mr. D. H. McCartney, a pasture biologist, to plan, develop, and coordinate a cow-calf management project.

Construction of the first phase of the animal research barn was started in the fall of 1973; the facilities for individually feeding 120 lambs in digestion stalls should be completed by the summer of 1974.

Further progress was made in planning a beef cow systems project in cooperation with the Saskatchewan Department of Agriculture. The purpose of this project is to study the effect of pasture management, winter housing, winter feeding, and breeding factors and their interaction on the economics of weaning calves.

The Station publishes "Research Highlights" each year. This publication provides more details of experiments than can be included in this report and is available by writing to the Director, Research Station, Agriculture Canada, Box 1240, Melfort, Sask. S0E 1A0.

S. E. Beacom
Director

FORAGE PRODUCTION AND UTILIZATION

Alfalfa Seed Production

Isolation distances when using leafcutter bees. A strain of white-flowered alfalfa, *Medicago media* Pers., was used to study the effects of isolation distance on contamination levels in alfalfa pollinated by the alfalfa leafcutter bee, *Megachile rotundata* Fabr. A 4-ha field of white-flowered alfalfa was grown beside a 4-ha field of blue-flowered alfalfa (cv. Beaver) providing a common border 140 m long. Because the flower color of the strain used in this study is controlled by a double recessive gene, the degree of contamination was easily determined by observing the flower color of its progeny. Both alfalfa fields were populated with 50,000 bees/ha.

Contamination within 3 m of the blue alfalfa was 17.1%. At distances of 10, 25, and 50 m, the contamination was 2.5, 1.1, and 0.8%. These results suggest that isolation distances of 10–25 m are satisfactory when alfalfa fields of 4 ha or larger are pollinated by the alfalfa leafcutter bee.

Effect of herbicides on seed yields. An established stand of alfalfa was treated with 2,4-DB at 0.4–2.1 kg/ha on four different dates. The treatments were made between May 7, when the alfalfa was just breaking dormancy, and June 11, when the alfalfa was

30 cm high. When the higher rates of herbicide were used on the later dates, the alfalfa showed moderate stem curling and some leaf loss. Seed yields varied from 90 kg/ha on areas treated with 2.1 kg of 2,4-DB on May 29 to 240 kg/ha on plots sprayed with 0.4 kg of herbicide on June 11.

When plots were treated with high rates of herbicide between May 7 and 29, seed yields were significantly lower than in similar plots that had been handweeded. The herbicide applied at 0.4 kg/ha on June 11 significantly increased seed yield, but higher rates on this date did not significantly affect seed yields.

In early spring 1973, the herbicides dichlobenil, diuron, asulam, simazine, and protham were applied to an alfalfa stand less than 5 cm high. Two rates of each chemical were used. None of the treatments had any significant effect on seed yields, which averaged 150 kg/ha. Dichlobenil caused some thinning of the stand. When 2,4-D was applied at rates of 0.6 and 1.1 kg/ha, the alfalfa was severely damaged early in the season, and the seed yield was reduced by 20%.

Production Management

Effects of soil moisture and amendments on yield and quality of alfalfa. Soil moisture and amendment treatments applied on three Gray Luvisol soils and one Dark Gray Luvisol significantly affected yield, protein, phosphorus, and sulfur contents of Rambler

alfalfa, *Medicago media* Pers. Low soil moisture tension (LSMT = 100 mb) resulted in higher yields than high soil moisture tension (HSMT = 151 mb). Application of manure (2.5% of soil wt) on Garrick clay loam and Arborfield clay under LSMT gave the highest yields. It was found that manure added more available phosphorus to the soils than did peat or straw. This partially explains the higher yield obtained with this treatment.

Protein content of the first-cut alfalfa (early bloom stage) was higher under HSMT than LSMT (31.1% vs. 29.7%) and was higher when ammonium nitrate (70 μ g N/g of soil) was applied (33.8% for cut 1, 28.7% for cut 2) than when manure or peat treatments were applied (28.3% and 29.9% for cut 1, and both 25.7% for cut 2). Protein content of the second cut was not significantly affected by soil moisture tension or soil type.

Phosphorus content of the alfalfa was higher under LSMT (0.33% for cut 1, 0.30% for cut 2) than under HSMT (0.29% for cut 1, 0.26% for cut 2) on Nipawin sandy clay loam (SCL). The manure treatment produced highest P forage (0.34% for cut 1, 0.32% for cut 2), the straw treatment the lowest (0.31% for cut 1, 0.28% for cut 2).

On the Nipawin SCL, sulfur content of the alfalfa averaged 0.35% and 0.32% for cuts 1 and 2 under HSMT and 0.31% and 0.30% for cuts 1 and 2 under LSMT.

Effect of companion crops. Wheat (*Triticum aestivum* L.) and rape (*Brassica napus* L. and *B. campestris* L.) used as companion crops in 1972 in the establishment of stands of brome grass (*Bromus inermis* Leyss.), Russian wild ryegrass (*Elymus junceus* Fisch.), alfalfa, and sainfoin (*Onobrychis viciaefolia* Scop.) caused dramatically lower forage yield in 1973 than comparable stands established without companion crops.

When seeded in 1972 without a companion crop, yields of brome grass, Russian wild ryegrass, alfalfa, and sainfoin in 1973 were 8,000, 3,500, 6,000, and 6,000 kg/ha. When rape was used as a companion crop, corresponding yields of the four forages were 3,000, 400, 950, and 1,000 kg/ha. A substantial volunteer population of rape suppressed the forages to some extent, but the stands were thin and the forage plants small at the start of the growing season. When wheat was used as a companion crop, brome grass and alfalfa yielded 4,000 and 3,500 kg/ha.

Harvesting

Hay-drying tower. A hay-drying tower patterned after one developed in Europe was constructed in cooperation with the Engineering Research Service during the summer of 1971. The system permits the drying of forage containing up to 50% moisture and maintains forage quality during storage. Modifications have been and will continue to be made to reduce the cost of the tower and the amount of labor required to operate it. The tower has a capacity of 80–90 t of dry forage (see Evaluation of Forage Harvesting Systems in this report).

Harvesting and storing hay. Crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), intermediate wheatgrass (*A. intermedium* (Host) Beauv.), and brome grass were harvested in 1972 with Hesston and McKee stacking wagons and with the conventional baler. Stacked hay was stored outside, and baled hay was placed in a shelter after weathering in the field for 2–3 wk. At the beginning of the storage period, digestibility of the forages was similar for all harvesting methods. Storage over winter only slightly reduced the digestibility of crested and intermediate wheatgrass. The decrease in digestibility of brome grass during storage was larger and baled hay appeared to deteriorate less than hay in the stacks. However, the poorer quality of hay in the stacks was probably largely due to the higher moisture content of the stacked hay at harvest. Protein content was not influenced by harvesting or storage method.

Effect of ensiling techniques on the feeding value of silage. Chopped sweetclover, *Melilotus officinalis* (L.) Lam., (31% DM) was ensiled in two horizontal bunker silos (5.5 m \times 14 m). The material in one silo was not packed, whereas that in the other was well packed. Half of the silage in each silo was treated with formic acid (0.45 kg/100 kg silage).

Losses due to spoilage were 4.5% and 13% of the DM ensiled for the packed and unpacked silage. The addition of formic acid had no effect on losses from spoilage.

Steers fed packed silage gained an average of 0.98 kg/day compared with 0.86 kg/day for those fed unpacked silage and they required approximately 15% less feed/kg of gain. The addition of formic acid had no effect on subsequent animal performance.

However, when the daily ration of steers fed acid-treated silage was supplemented with 1.4 kg of barley, the average daily gains increased by 16% over gains made by steers fed either packed or unpacked silage without the acid treatment.

Utilizing Pastures

Continuously grazed brome-grass-alfalfa vs. rotational three-pasture system. A continuously grazed sward of brome-grass and alfalfa was compared with two pasture treatments in which separate paddocks of crested wheatgrass and alfalfa, brome-grass and alfalfa, and Russian wild ryegrass alone were grazed in rotation by yearling Hereford steers. In one of the rotationally grazed treatments, Russian wild ryegrass was harvested for seed before grazing, whereas in the other treatment it was utilized as pasture only. The 7-yr average dry matter yields and steer gains were 4,794 and 326 kg/ha for the continuously grazed brome-grass-alfalfa; 3,949 and 343 kg/ha for the treatment in which Russian wild ryegrass was used only for pasture; and 3,325 and 277 kg/ha for the treatment in which Russian wild ryegrass was harvested for seed before being used as pasture. Harvesting seed from Russian wild ryegrass reduced the dry matter available for grazing from 3,603 to 3,183 kg/ha and the liveweight gain from 295 to 168 kg/ha; the seed yield averaged 410 kg/ha.

Cereal varieties as pasture. Three 0.32-ha plots of Fraser (oats), IH 1863-4 (oats), Pitic 62 (wheat), and Glenlea (wheat) were grazed in rotation by weaned lambs (22 lambs/ha). Dry ewes were used to graze excess forage. Dry matter production was 7,053, 7,301, 7,201, and 5,655 kg/ha and lambs gained 274, 259, 235, and 242 kg/ha on the four varieties. When the dry matter eaten by the ewes is taken into consideration, the lamb gains increased to 365, 342, 288, and 301 kg/ha.

Utilizing Harvested Forages

Ground hay in finishing rations for beef steers. Four lots of 12 Charolais crossbred steers, averaging 350 kg, were started on rations containing 50, 70, 80, and 90% ground (1.27-cm screen) good-quality grass hay, and over 8, 105, 112, and 126 days were gradually changed to rations containing 10% straw, 10% straw, 10% hay plus 10% straw, and 30% hay. Over the 147-day feeding

period consumption of roughage averaged 11, 37, 51, and 65% of the total rations. The remainder of the ration contained rolled grain (equal parts of barley and wheat), tallow (1.5%), minerals, vitamin A, and an antibiotic. Average daily gains were 1.54, 1.56, 1.45, and 1.39 kg; feed-to-gain ratios were 7.0, 7.9, 8.5, and 8.8; and daily feed consumption 10.7, 12.3, 12.4, and 12.3 kg. Dressing percentages averaged 56.3, 55.8, 56.1, and 56.5, and carcass grades were almost equal. At a cost of grain at 10.1¢/kg (4.6¢/lb) and hay at \$30/t (2,200 lb), returns over the cost of the feeder animal, feed, and feed processing averaged \$12.44, \$14.87, \$24.42, and \$30.58/steer for the four rations. Expressed another way, ground hay was worth \$32, \$40, and \$43/t when fed in rations 2, 3, and 4.

Anabolic implants for finishing beef steers. In the experiment just described, one-third of the steers in each ration group was implanted with 36 mg of Ralgro (Zeranol; Commercial Solvents Corporation), one-third with 200 mg of progesterone and 20 mg of estradiol benzoate (Synovex S; E. R. Squibb & Sons), and one-third left as unimplanted controls. Average daily gain was 1.56, 1.54, and 1.37 kg; and dressing percentage averaged 56.2, 56.7, and 55.5. The difference between implanted and unimplanted steers probably was due to the heavier weight (20 kg or more) of the implanted steers. Grades were comparable between treatments except that more of the carcasses from implanted steers were in the heavy categories of the A1 and A2 grades. There was an indication that the implants had more effect on increasing the rate of gain of steers fed the ground, high-roughage ration than on those fed the high-concentrate ration.

Evaluation of forage harvesting systems. Brome-grass-alfalfa was cut and allowed to field cure in the windrow until it was suitable for storing as silage (at 65% moisture); as chopped hay, artificially dried in a hay tower (at 40% moisture); as stacked long hay (at 25% moisture); and as bales (at 20% moisture).

In the first year of this test, average daily gains of steer calves fed artificially dried hay were 0.82 kg, bales 0.74 kg, stacks 0.74 kg, and silage 0.64 kg. Feed required per unit of gain for the four treatments was 8.7, 9.1, 9.8, and 10.3, and kg of gain/t (2,200 lb) of

forage DM harvested were 113, 111, 102, and 87.

Alfalfa pellets vs. alfalfa cubes for beef steers. Suncured alfalfa pellets (1.3 cm diam) and cubes (3.2 cm²) were fed at up to 70% of the ration with dry-rolled barley to long-yearling Hereford steers. Suncured pellets fed at 10% produced gains similar to those of steers fed 10% ground wheat straw but they improved feed efficiency by approximately 5%. Between 31% and 69% of the steers were treated at least once for bloat when fed rations containing 40% and 70% alfalfa pellets or cubes.

CEREAL AND SPECIAL CROP PRODUCTION AND UTILIZATION

Variety Testing

Wheat. An FMQ (fair milling quality) wheat selection, N.B.-106, developed at the University of Manitoba, outyielded Pitic 62 by 6% and Napayo, a bread wheat, by 28%. This white-kernel wheat selection matured 8 days earlier than Pitic 62 and, because of its shorter straw, was much more resistant to lodging.

Winter wheat. Two new cultivars of winter wheat from the USSR, Ulianovka and Alabaskajo, had excellent winter survival but yielded 5% and 10% less than Kharkov.

Barley. At three sites in northeastern Saskatchewan, B.T. 313, a new malting and brewing selection from Brandon, Man., outyielded Conquest (the standard) by 10% and Bonanza (the previous high yielder) by 5%. The maturity and height of B.T. 313 was equal to that of Bonanza but it had stronger straw.

Oats. O.T. 618, an oat selection developed at Melfort, outyielded the standard variety, Garry, by 18% and Random and Fraser by 2% and 6%.

Rapeseed. Midas, *Brassica napus* L., outyielded Target (the standard) by 2% but was 13% lower than Zephyr.

Fababeans. In Canada the three varieties of fababeans licensed for sale are Erfordia, Akerperle, and Diana; in 1973, they yielded 5,097, 4,670, and 4,521 kg/ha.

Production Management

Crop sequence studies. At Somme, Sask., a 6-yr grain-forage rotation on a heavy-textured Gray Luvisol soil produced a net return of \$111.47/ha as compared with \$87.73/ha for a 3-yr straight grain rotation (when wheat was valued at 7.7¢/kg and hay (DM) at 4.4¢/kg over the past 17 yr). At Archerwill, on a lighter textured Gray Luvisol soil, the net return was \$67.36 for a 6-yr grain-forage rotation as compared with \$41.00/ha for a 3-yr straight grain rotation. The difference between straight grain and grain-forage rotations is not as great on the Black soil at Melfort as on Gray Luvisol soils. In addition to increased returns the grain-forage rotations have also increased the nitrate content of the soil and protein content of the grain.

Trash management for cropping. Analysis of 18 years' data from a continuous wheat rotation has shown that spring burning, fall tillage with a discer, and fall tillage with a cultivator produced the highest yields at Melfort. Burning stubble is not generally recommended because of its effect on soil organic matter, but it is sometimes done to desiccate weed seeds and to reduce the trash cover. Average yields of the continuous wheat treatment in this study were 1,848 kg/ha for land that was plowed each fall; 1,808 kg/ha for fall tillage with a discer; 1,937 kg/ha for fall tillage with a cultivator; and 2,016 kg/ha for land that was burned each spring. A soil-incorporated liquid herbicide, triallate, was used for controlling wild oats, *Avena fatua* L., in this study. It was more effective in plots that were fall tilled with a discer or plow and where the stubble was burned in the spring before incorporating the herbicide than when the stubble was left standing.

Controlling wild oats in rape. Triallate at 1.7 kg/ha and trifluralin at 1.4 kg/ha applied in the fall gave 75% control of a serious infestation of wild oats in rape, *B. campestris* L., on Melfort silty clay loam. Over the 2 yr of the test, the average crop yield was increased 49% by the trifluralin and 26% by the triallate treatments. Trifluralin is also used for the control of certain broadleaf weeds.

Relation of yield response to soil tests for phosphate and nitrogen. Yield response of Manitou wheat to phosphate fertilizer was significantly related to amounts of sodium-bicarbonate-soluble phosphorus (negatively),

nitrate-nitrogen (positively), and exchangeable ammonium-nitrogen (negatively) in the soil. Yields on control plots were positively related to sodium-bicarbonate-soluble phosphorus (0-15 cm deep) in the soil ($R^2 = 64.3\%$). Confidence intervals of predicted yield response were large. This was attributed to variation in soil and climate.

Crop Utilization and Animal Nutrition

Dehydrated alfalfa vs. rapeseed meal as supplements in rations for beef cattle. Groups of long-yearling steers were fed chopped wheat straw ad lib. plus either rapeseed meal (RSM) (0.57 or 1.13 kg/head daily) or levels of dehydrated alfalfa (dehy) to provide equivalent levels of crude protein (1.13 or 2.26 kg/head daily). Results indicated that when utilized as a protein supplement in a maintenance ration, the value of dehy is 60-65% that of RSM per unit of wt.

The addition of equivalent levels of supplementary protein (0.45 kg 32% beef supplement or 0.45 kg RSM or 0.9 kg dehy) to a basal ration consisting of 15% ground wheat straw and 85% barley increased liveweight gain of long-yearling beef steers by 23.5, 22.2, and 39.5%. Feed intake and feed efficiency were also improved by addition of supplementary protein to the basal ration.

Utilization of fababeans (horsebeans) by market pigs. Fababeans, variety Ackerperle, grown under irrigation at Outlook, Sask., were included as 0, 7.5, 15, and 30% of 16%-protein diets, based on barley and soybean meal (SBM), fed ad lib. to pigs from 25 to 91 kg liveweight. A similar experiment was conducted to compare the performance of pigs fed diets containing 15% fababeans or field peas grown without irrigation at Melfort.

Increasing the dietary level of fababeans from 0 to 30% significantly reduced ($P < 0.01$) the growth rate up to 50 kg liveweight but had no significant effect on overall gains (0.76 kg/day). The diet containing 7.5% fababeans and 12% SBM was most efficiently utilized (3.30 kg feed/kg gain). Carcass quality tended to improve ($P < 0.05$) as fababeans replaced SBM as the source of supplementary protein. Average carcass value indexes ranged from 103.5 with the basal diet (15% SBM) to 106.6 (30% fababeans).

When used as 15% of the diet, field peas resulted in similar gains (0.78 kg/day) and feed-to-gain ratios (3.57) but higher carcass value indexes (106.6 vs. 105.1) than fababeans.

Although fababeans have a lower protein content (25-30%) than SBM (44-50%), they appear to be a satisfactory alternative source of supplementary protein for market pigs.

PUBLICATIONS

Research

Beacom, S. E., and Thorlacius, S. O. 1973. Effect of pelleting, roughage level and hormone implantation on the utilization of finely ground crested wheatgrass by growing lambs. *Can. J. Anim. Sci.* 53:725-731.

Cooke, D. A., Beacom, S. E., and Robertson, J. A. 1973. Comparison of continuously grazed brome-grass-alfalfa with rotationally grazed crested wheatgrass - alfalfa, brome-grass-alfalfa and Russian wild ryegrass. *Can. J. Anim. Sci.* 53:423-429.

Friesen, H. A., and Bowren, K. E. 1973. Factors affecting the control of wild oats in rapeseed with trifluralin. *Can. J. Plant Sci.* 53:199-205.

Nuttall, W. F. 1973. Yield response of Conquest barley as affected by nitrogen fertilizer and soil tests for ammonium- and nitrate-nitrogen. *Can. J. Soil Sci.* 53:163-168.

Nuttall, W. F. 1973. The influence of soil moisture tension and amendments on yield, oil and protein content of Target rape grown on Gray Wooded soils in the greenhouse. *Can. J. Soil Sci.* 53:87-93.

Thorlacius, S. O., and Lodge, G. A. 1973. Absorption of steam-volatile acids from the rumen of the cow as influenced by diet, buffers and pH. *Can. J. Anim. Sci.* 53:279-288.

Waddington, J. 1973. Use of factor analyses to investigate relations between environmental variables and forage yield. *Can. J. Plant Sci.* 53:309-316.

Walkof, C., Anderson, R. H., and Allen, H. T. 1973. Three bush-type tomato cultivars: Melfort, Booster, and Pembina. *Can. J. Plant Sci.* 53:643-644.

Miscellaneous

- Beacom, S. E. 1973. Roughage in steer finishing rations. *Canadex* 420.60.
- Beacom, S. E. 1973. Cut steer feeding costs. *Canadex* 420.60.
- Bowren, K. E. 1973. Harvesting rapeseed. *Canadex* 149.50.
- Castell, A. G. 1973. Effect of starter rations on overall performance of pigs. *Canadex* 440.60.
- Castell, A. G. 1973. Rapeseed as a source of nutrients for pigs. *Canadex* 440.64.
- Cooke, D. A., Goplen, B. P., and Pankiw, P. 1973. Isolation distances for sweetclover seed production. *Canadex* 123.15.
- Feldman, M., and Beacom, S. E. 1973. Effect of harvesting equipment and bale management methods on hay quantity and quality. Paper No. 73-310. *Annu. Conf. Can. Soc. Agric. Eng., Victoria, B.C.*
- Goplen, B. P., Cooke, D. A., and Pankiw, P. 1973. Isolation distances required for sweetclover seed production. *Can. Agric.* 18(3):13-14.
- Jackson, H. A., and Beacom, S. E. 1973. Progress in the development of a hay tower for drying, storing and mechanically handling chopped hay. Paper No. 73-501. *Annu. Conf. Can. Soc. Agric. Eng., Victoria, B.C.*
- Jackson, H. A., and Robertson, J. A. 1973. Comparison of packed and non-packed storage of silage in horizontal silos in a cold climate. Paper No. 73-215. *Annu. Conf. Can. Soc. Agric. Eng., Victoria, B.C.*
- Jackson, H. A., and Robertson, J. A. 1973. Packed vs. unpacked silage. *Canadex* 120.52.
- Nuttall, W. F. 1973. Estimated yield response to N fertilizer. *Canadex* 530.
- Robertson, J. A. 1973. Digestibility of rapeseed screenings. *Canadex* 149.81.
- Robertson, J. A. 1973. A comparison of four systems of managing steers on pasture. *Canadex* 420.60.
- Robertson, J. A. 1973. Rapeseed meal vs. dehydrated alfalfa as supplement for beef cattle. *Canadex* 420.60.
- Thorlacius, S. O. 1973. Effect of harvesting and storage of hay on growth of lambs. *Canadex* 430.61.
- Thorlacius, S. O. 1973. Sheep on forage oat pasture. *Canadex* 430.62.

Research Station Regina, Saskatchewan

PROFESSIONAL STAFF

J. R. HAY, B.S.A., M.S., Ph.D.

Director

Biological Control of Weeds

P. HARRIS, B.S.F., D.I.C., Ph.D.

Head of Section; Biological
control—weeds

M. G. MAW, B.Sc., M.Sc.

Biological control—weeds

D. P. PESCHKEN, B.S.A., M.Sc., Dr.Sci.Agr.

Biological control—Canada thistle

Weed Control

J. D. BANTING, B.S.A., M.Sc., Ph.D.

Head of Section; Weed science—
annual grasses

K. F. BEST, B.S.A., M.Sc.

Weed biology

G. G. BOWES, B.S.A., M.Sc.

Weed science—range weeds

J. H. HUNTER, B.S.A., Ph.D.

Weed science—agronomy

G. I. MCINTYRE, B.Sc., Ph.D.

Weed biology

E. S. MOLBERG, B.S.

Weed science—agronomy

Herbicide Behavior in the Environment

R. GROVER, B.Sc., M.Sc., Ph.D.

Head of Section; Availability,
mobility, monitoring

G. S. EMMOND, B.S.A., M.Sc.

Residues

A. E. SMITH, B.Sc., Ph.D.

Residues, metabolism, methodology

Seed Section

E. D. MALLOUGH, B.S.A.

Head of Section; Distribution

G. R. BOUGHTON, B.S.A., M.Sc.

Verification

Experimental Farm, Indian Head, Sask.

R. N. MCIVER, B.S.A.

Officer-in-charge; cereals, crop
management

Departures

E. BUGLASS, B.S.A.

Retired April 1973

Acting Director, Experimental
Farm, Indian Head

S. U. KHAN, B.Sc., M.Sc., Ph.D.

Transferred to Chemistry and Biology Research
Institute, August 1, 1973

Adsorption mechanisms

VISITING SCIENTIST

D. E. BERUBE, B.S., M.A., M.Phil., Ph.D.

National Research Council postdoctorate fellow

Biological control

INTRODUCTION

This is a report of the work done in 1973 at the Research Station, Regina. The Station is the main center for weed control research in Canada, with a complement of 13 scientists specializing in various aspects of weed science. As well as solving the immediate weed problems of Prairie farmers, we are doing backup research to ensure that harmful consequences do not arise as a result of new weed control technology. Research is conducted on control of weeds in crops and on grazing land, on biological control of weeds, on the persistence and movement of herbicides in the environment, and on the biology of the weeds themselves.

The Station also increases and distributes Breeder seed and the seed of the new varieties of cereal, forage, and oilseed crops developed by the Branch.

During the year, the Experimental Farm at Indian Head became a substation of this Station, with Mr. R. N. McIver as officer-in-charge. The Farm will continue to do research on cropping practices and to evaluate cereal, oilseed, and forage crops for southeastern Saskatchewan.

Mr. E. Buglass retired in April after many years of faithful service as a forage agronomist and breeder. He also served admirably as Acting Director of the Experimental Farm at Indian Head for one year before his retirement.

Detailed information on research results can be obtained from the scientists. The address of this establishment is: Research Station, Research Branch, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2.

J. R. Hay
Director

BIOLOGICAL CONTROL

Insects were collected on the weeds given priority for biological control. This survey and others in various parts of the world indicated that the hoary cresses are not promising candidates for biological control, so that work was discontinued on the three species involved. Insects of note were a gall midge found in 20% of the seed heads of absinthe in Saskatchewan, and the fly *Paroxyna americana* Her. in dandelion seed heads in northern British Columbia and Alberta. In southern Saskatchewan, 40% of the dandelion heads were attacked by the weevils *Ceutorhynchus marginatus* Payk. and *Otiorrhynchus ovatus* (L.), and the leaf-gall wasp, *Gillettea taraxaci* Ashm. destroyed 10% of the dandelions in irrigated alfalfa. The moth *Melitara prodenialis* Walk. destroyed about 90% of the prickly-pear pads near Buffalo Pound Lake, Sask.

Laboratory colonies were established for host screening tests of a European moth, *Cucullia verbasci* L., that feeds on mullein leaves; a European fly, *Tephritis dilacerata* Loew., that attacks the seed heads of perennial sow-thistle; a Japanese stem-boring

moth, *Porphyria amasina* Evers., for Canada thistle; and a European root-boring beetle, *Oberea* sp., for leafy spurge. Studies on the beetle *Sphenoptera jugoslavica* Zell. for diffuse knapweed were discontinued in the hopes of importing a more damaging insect. Screening tests were started with the gall nematode *Paranguina picridis* Kirj on Russian knapweed. A European tingid, *Tingis ampliata* (H.-S.), that attacks Canada thistle was shown to develop on both safflower and globe artichoke and hence to be unsuitable for biological control in North America; the stem-gall fly of thistles, *Urophora cardui* (L.), did not develop on any of the crop plants tested. Screening tests on the European tortoise beetle, *Cassida hemisphaerica* Hbst. on bladder campion, showed that it would develop on several plants in the genera *Silene* and *Dianthus*. It also fed on beet leaves, although the larvae did not develop on this plant.

Releases were made of the following biological control agents not currently established in Canada: in British Columbia, the seed-head fly *Urophora stylata* (Fabr.) on bull thistle; the seed moth *Metzneria paucipunctella* Zell. on spotted knapweed; the beetle *Longitarsus jacobaeae* Watr. on tansy

ragwort; and in Saskatchewan, the root-boring moth *Champaesphesia empiformis* Esp on leafy spurge; the moth *Calophasia lunula* (Hufn.) on toadflax; and the stem weevil *Ceutorhynchus litura* (F.) on Canada thistle. Also, the beetle *Chrysolina hyperici* (Först) on St. John's-wort in New Brunswick was reinforced with additional stock from the west coast.

The spurge hawkmoth *Hyles euphorbiae* (L.) had a density of 0.4 larvae/m² and had spread to the limits of the cypress spurge infestation (75 km²) at Braeside, Ont. In cooperation with the University of Guelph, larvae were moved to other infestations of cypress spurge in Ontario.

The seed-head fly *Urophora affinis* Frfld. increased from 3.8 to 7.4 galls/100 heads on spotted knapweed at Chase, B.C., and from 1.7 to 12.7 galls/100 heads on diffuse knapweed at Pritchard, B.C.

The seed-head weevil of nodding thistle, *Rhinocyllus conicus* Fr., increased from 29 to 109 larvae/100 heads at Craik, Sask. *R. conicus* is likely to reduce seed production of this biennial weed substantially, and distribution to other infestations in Saskatchewan, Manitoba, and Quebec is recommended.

Tansy ragwort has almost disappeared at the original release sites of the cinnabar moth, *Tyria jacobaeae* (L.), in Nova Scotia and Prince Edward Island. The moth is being distributed by local authorities and appears likely to control the weed throughout the Maritime Provinces on well drained, nonarable areas. Unfortunately, it is less effective in British Columbia.

WEED CONTROL

Crop tolerance for new herbicides. Under weed-free conditions, wheat tolerated post-emergence applications of MC 4379 at 0.84 kg/ha (12 oz/ac); BAS 3581 at 1.68 kg/ha (24 oz/ac); M 3785 and M 3786 at 0.35 kg/ha (5 oz/ac); and WL 26624, WL 29761, and HOE 23408 at 1.12 kg/ha (1 lb/ac). Wheat was not tolerant of M 3785 and M 3786 at 0.70 kg/ha (10 oz/ac), or of R-4572 + propanil at 5.6 kg/ha (5 lb/ac).

Noralta flax tolerated BAS 3510-H at 2.24 kg/ha (32 oz/ac) and a mixture of bromoxynil and diuron at 0.51 + 0.61 kg/ha (7.3 + 8.7 oz/ac). Herbicide treatments that caused

significant delays in maturity but not reductions in yield included MBR 8251 at 2.24 kg/ha (32 oz/ac), AC 84777 at 0.56 kg/ha (8 oz/ac), a tank mixture of asulam, bromoxynil, and MCPA ester at 1.12 + 0.28 + 0.28 kg/ha (16 + 4 + 4 oz/ac), and a mixture of linuron and MCPA amine at 0.28 + 0.56 kg/ha (4 + 8 oz/ac). Treatments that decreased flax yields significantly included MBR 8251 at 4.48 kg/ha (4 lb/ac) and AC 84777 at 1.12 kg/ha (16 oz/ac). No wetter was used with the AC 84777.

Wild oats. In field trials, control of wild oats with WL 26624 and WL 29761 at 0.84 kg/ha (12 oz/ac) was equal to that obtained with barban at 0.35 kg/ha (5 oz/ac) and superior to control with WL 17731 at 1.40 kg/ha (20 oz/ac). Control with AC 84777 at 0.84 kg/ha (12 oz/ac) and R-21403 at 4.5 kg/ha (4 lb/ac) was unsatisfactory. In greenhouse tests, no wild oats headed when AC 84777 was applied at 0.67 kg/ha (9.6 oz/ac) at the two-leaf stage and wild oats were controlled with R-21403 at 4.48 kg/ha (4 lb/ac).

The addition of an amine of MCPA to asulam increased control of wild mustard but not of wild oats in flax. Based on the dry weight of wild oats at harvest, barban at 0.35 kg/ha (5 oz/ac) gave 96% control, asulam alone at 1.12 kg/ha (16 oz/ac) gave 91% control, and the asulam with MCPA at 0.28 kg/ha (4 oz/ac) gave 87% control.

MBR 8251, a soil-applied compound, was effective against wild oats and green foxtail in the greenhouse only at a rate of 4.48 kg/ha (4 lb/ac) or more. Wheat was damaged at 4.48 kg/ha but flax tolerated a higher rate. In other tests, Buban 37 was more active in sandy loam than in heavy clay and was more effective against green foxtail than against wild oats.

When barban was applied with flat fan 650067, floodjet TK 75, and whirlchamber 61 × 61 nozzles, wild oat control was best with the flat fan and poorest with the whirlchamber nozzles.

Leafy spurge. Seven days after foliar application of ¹⁴C-labeled 2,4-D, 48% and 75% of the ¹⁴C in the shoot and root extracts, respectively, were identified chromatographically as 2,4-D. Decapitation of the shoot before the herbicide application significantly increased the amount of the tracer translocated out of the treated leaves; as a result, considerably higher levels of ¹⁴C appeared in

the shoot, roots, and root buds after a period of 3 days. Increasing the nitrogen supply to the root medium 15 days before 2,4-D was applied had a similar effect on translocation. The similarity in effects of shoot decapitation and increased nitrogen supply on ^{14}C distribution was attributed to the marked promotion of bud growth by both of these treatments.

Povertyweed. Annual applications of esters of 2,4-D at 2.24 kg/ha (2 lb/ac) or 2,4-DB at 1.68 kg/ha (1.5 lb/ac) over a period of 4 yr eliminated 99 to 100% of povertyweed (*Iva axillaris* Pursh) growing in a mixture of crested wheatgrass, smooth brome grass, tall wheatgrass, and intermediate wheatgrass, on saline, heavy clay soil. Dicamba at 2.8 kg/ha (2.5 lb/ac) applied every 2nd yr also gave a continuous high degree of control. Results with picloram were variable, but 0.84 kg/ha (12 oz/ac) gave good control for 1 yr or more with occasional injury to the grass. In these tests the herbicides were applied in July.

In another test on saline soil, annual yields of crested wheatgrass, originally infested with povertyweed (30 shoots/m²), were increased from 686 to 1,790 kg/ha (611 to 1,593 lb/ac) when ammonium nitrate fertilizer was applied annually at 78 kg N/ha (70 lb/ac) over a 3-yr period. Applying 2,4-D or 2,4-DB at 1.68 kg/ha (1.5 lb/ac) annually for this period gave 60 to 84% control of topgrowth in povertyweed but did not increase grass yields.

Chemical summerfallow. Asulam controlled volunteer wheat on summerfallow when it was applied at the four-leaf stage alone at 2.24 to 4.48 kg/ha and at 3.36 kg/ha in a mixture with 2,4-D at 1.12 kg/ha. In another test, MON 2139 applied at 0.84 kg/ha and 1.12 kg/ha on June 21 controlled all the weeds present until late July. The 0.56-kg/ha rate was not sufficient to control wild buckwheat, Russian thistle, or kochia. Late-emerging weeds, including the pigweeds and thyme-leaved spurge, were not affected.

In a fallow-wheat rotation, wheat yields after chemical fallow have been significantly higher in 2 out of 4 yr than after conventional fallow by tillage. In a 3-yr period, 87% of the original plant residue was conserved by chemical fallow compared with 33% for the cultivated fallow. The herbicide treatment in this experiment was a mixture of paraquat at 1.12 kg/ha and a commercial

product containing 0.28 kg bromoxynil and 0.28 kg MCPA/ha.

Ecological studies of annual weeds. All spring-emerging stinkweed seedlings exhibited early-flowering behavior, although both early and late-flowering strains were present. This phenotypic uniformity was a result of natural vernalization, as indicated by laboratory experiments in which earlier flowering of the late-flowering type was promoted by low-temperature treatments of seedlings. High temperatures accelerated flowering and decreased leaf number of plants of the early-flowering genotype but had the opposite effect on the late-flowering strain. A constant temperature of 25°C in light gave approximately 45% germination of early-flowering plants but no germination of the late-flowering strain. With alternating temperatures (10–25°C), both strains gave 95–100% germination in the light but very low germination in the dark. Flixweed plants from seed sown in the field in late spring required more than 90 days to flower whereas seedlings, emerging in the spring from naturally vernalized seed, flowered within 45 days.

Regenerative potential of perennial weeds. The number of buds on the roots of leafy spurge seedlings was significantly increased by reducing the daylength or by increasing the nitrogen supply under long days. The positive correlation of nitrogen and light intensity with the number of root buds was attributed to the production of bud-bearing lateral roots. In milkweed, the number of root buds was significantly increased by lowering the N supply and reduced by lowering the light intensity. Root buds were not associated with lateral roots as in other species, and appeared to be exogenous in origin.

Effect of brush control on forage yield. Forage yields were obtained from community pastures 4 and 5 yr after spraying. The experimental areas were cleared of brush, disced, and seeded to a mixture of alfalfa and brome grass before treatment. Picloram and 2,4-D applied during the summer eliminated alfalfa from forage stands. The grass component increased after the application of picloram but remained unchanged after 2,4-D. The total forage yield after application of picloram was similar to that of the untreated areas but there was a net loss of forage after application of 2,4-D. The applications of

phenoxy herbicides during the dormant season left the alfalfa in the stand but did not effectively control prickly rose. Data for 1 yr showed that five times more alfalfa grew in open spaces between aspen and prickly rose than directly under the shrubs. The weights of bromegrass growing under prickly rose and aspen poplar, and in the open spaces, were similar.

Competition studies. Flax was infested with 3 to 300 wild mustard plants and 1 to 100 wild oat plants per square metre. The mustard emerged 5 days and the wild oats 7 days before the flax. At 3, 10, and 300 mustard plants/m², yields were reduced by 18, 59, and 94%, respectively. Reductions from infestations of 3 to 100 wild oats/m² were 27 and 89%.

In a similar study of wild oats in wheat, yield reductions ranged from about 16% where there were 11 wild oats/m² to over 70% with 276 wild oats/m². In this test the wild oats emerged 2 days after the wheat.

Weed survey. Wild mustard, wild oats, stinkweed, and cow cockle were the most common weeds found in 23 flax fields that were sampled near Regina in late June 1973. These four species made up more than 90% of the weed growth. Altogether, 18 weed species were encountered. Redroot pigweed and wild buckwheat were prevalent in more than 40% of the fields. The average number of weeds was 27/m², and the density varied from 2 to 141/m².

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Air-monitoring for 2,4-D. At three sites in southern Saskatchewan, the butyl ester of 2,4-D was detected on a number of days during the spraying season, with concentrations ranging from trace amounts to as high as 6.75 $\mu\text{g}/\text{m}^3$. Total 2,4-D in some samples was determined and found to be present in higher amounts than butyl esters alone, the highest being 11.5 $\mu\text{g}/\text{m}^3$. This was attributed to possible partial hydrolysis of the esters, either on the sampling medium or in the air before it was sampled.

Residues, persistence, and degradation in soils. Several herbicides were applied in the fall to small plots at three locations. Over 75% of simazine and 30 to 50% of diallate, triallate, trifluralin, dichlobenil, linuron, and

USB 3584 were recovered the following spring. No 2,4-D or dicamba residues were found.

When these herbicides were applied in May at three sites, no residues of 2,4-D, dicamba, or diallate were observed in the top 5 cm of soil in October. Of the remaining compounds, simazine was again the most persistent; 25% or less of the other herbicides remained. After two growing seasons, 20% of simazine and less than 10% of triallate, trifluralin, dichlobenil, linuron, and USB 3584 were still present in the top 5 cm of the soils. No residues were observed in the soil at a depth of 5–10 cm.

Atrazine was applied in May 1972 at three locations in Manitoba. Residues were present in the spring of 1973.

The persistence of TCA in three prairie soils was investigated under laboratory conditions. Degradation was most rapid on soils high in organic matter and complete breakdown of the herbicide occurred within 3 wk at moisture levels higher than wilting point. On other soils breakdown was somewhat slower.

In *in vitro* studies with an unidentified soil organism, the amide and acid analogues of bromoxynil were identified as the breakdown products of bromoxynil. The breakdown of the herbicide was rapid, only 5% of bromoxynil remaining in the culture medium after 5 wk.

Droplet drift potential from conventional sprayers. In cooperative field experiments with the Saskatchewan Research Council, the initial drift of 2,4-D from a conventional farm sprayer was about 3% when the material was sprayed at 1.75 kg/cm² (25 psi) and 56 litres/ha (5 gal/ac), at wind speeds of 8–16 km/h (5–10 mph). This drift fraction was nearly doubled when the hydraulic pressure was increased to 2.8 kg/cm² (40 psi), and reduced by a factor of 4 when the herbicide was applied at 112 litres/ha (10 gal/ac). About 25 to 40% of the amount drifting was still in the air 1,000 m downwind, indicating that considerable amounts of spray may be blown from a field even from swaths that are well upwind of the field edge. Up to 20% of the sprayed area received less than half the expected rate of application.

Interactions of herbicides with soils. There was little or no adsorption of the acid and dimethylamine forms of dicamba on several

soils studied. However, the dimethylamine cation was highly adsorbed. The results were explained on the basis of the dissociation of both forms to the anionic species under the moist soil conditions.

The relative adsorption of seven urea herbicides on several soils was in the following order of increasing adsorption: fenuron < monuron < monolinuron < metobromuron < diuron < linuron < chlorbromuron. The *Q* values (μ g adsorbed per gram of organic matter) ranged from 24 to 437.

Paraquat and diquat formed complexes with humic and fulvic acid compounds of the soil by the mechanisms of ion exchange and charge transfer, whereas adsorption of 2,4-D and picloram to humic acid involved only physical forces.

A study of the complexes formed by triallate with cation-saturated montmorillonite indicated that the herbicide was coordinated with the exchange cation on the clay by the oxygen of the carbonyl group.

SEED SECTION

Increase and distribution. Three new strains of rapeseed, as well as the usual plant breeding material, were increased in California: Midas, a *Brassica napus* type of rapeseed, was grown on 117 ha (290 ac) and

returned to Canada for release as a new variety, and two low-erucic-acid, low-glucosinolate strains of *B. napus* were multiplied on 4 ha (10 ac) and returned to Canada for further increase under contract. The buckwheat strain MB-1 was increased on 1 ha (2.5 ac) in Florida and returned to Canada for further increase under contract. The winter increase of corn has expanded to 0.4 ha (1 ac) in Hawaii. Two corn breeders are now using this service.

Breeder seed of a new *B. hirta* mustard (No. 1241) is under increase on 0.4 ha (1 ac) in New Zealand. Seed from this plot will be returned to Canada and increased further under contract before release.

Seven new cultivars were distributed: Wakooma durum wheat, Hector two-row barley, Hinoat oats, Vanier barley, Gemini oats, Triumph peas, and Torch (*B. campestris*) rapeseed. Seed of these cultivars was made available to seed growers and members of the seed trade across Canada.

The Breeder seed maintenance program continued to expand and now contains 74 cultivars of 14 different kinds of crop. In 1973, 3,946 kg (8,699 lb) of Breeder seed representing 34 cultivars of 10 different crops were distributed to Canadian seed growers.

In 1973, 108 requests were received from Canada and six foreign countries for seed for experimental purposes. We supplied 4,269 kg (9,411 lb) of seed from 52 cultivars.

MANUFACTURERS OF HERBICIDES IDENTIFIED BY CODE OR TRADE NAME

<i>Code or trade name</i>	<i>Manufacturer</i>
AC 84777	Cyanamid of Canada Ltd.
BAS 3510-4, BAS 3581	BASF Canada Ltd.
Buban 37	Buckmann Laboratories
HOE 23408	Hoechst Canada Ltd.
M 3785, M 3786	Dow Chemical Co.
MBR 8251	3M Canada Ltd.
MC 3479	Fisons Canada Ltd.
MON 2139	Monsanto Canada Ltd.
R-4572, R-21403	Stauffer Chemical Co.
USB 3584	U.S. Borax and Chemical Co.
WL 17731, WL 26624, WL 29761	Shell Canada Ltd.

PUBLICATIONS

Research

- Banting, J. D., Molberg, E. S., and Gebhardt, J. P. 1973. Seasonal emergence and persistence of green foxtail. *Can. J. Plant Sci.* 53:369-376.
- Best, K. F., and McIntyre, G. I. 1972. Studies on the flowering of *Thlaspi arvense* L. I. The influence of some environmental and genetical factors. *Bot. Gaz.* 133:454-459.
- Grover, R. 1973. The adsorptive behavior of acid and ester forms of 2,4-D on soils. *Weed Res.* 13:51-58.
- Grover, R. 1973. Movement of picloram in soil columns. *Can. J. Soil Sci.* 53:307-314.
- Hurd, E. A., Townley-Smith, T. F., Mallough, E. D., and Patterson, L. A. 1973. Wakooma durum wheat. *Can. J. Plant Sci.* 53:261-262.
- Khan, S. U. 1973. Interaction of bipyridylum herbicides with organo-clay complex. *J. Soil Sci.* 24:244-248.
- Khan, S. U. 1973. Interaction of S-2,3,3-trichloroallyl N,N-diisopropylthiolcarbamate (triallate) with montmorillonite. *J. Environ. Qual.* 2:415-417.
- Khan, S. U. 1973. Interaction of humic substances with bipyridylum herbicides. *Can. J. Soil Sci.* 53:199-204.
- Khan, S. U. 1973. Equilibrium and kinetic studies of the adsorption of 2,4-D and picloram on humic acid. *Can. J. Soil Sci.* 53:429-434.
- McIntyre, G. I. 1973. Environmental control of apical dominance on *Phaseolus vulgaris*. *Can. J. Bot.* 51:293-299.
- Peschken, D. P., and Beecher, R. W. 1973. *Ceutorhynchus litura* (Coleoptera: Curculionidae): Biology and first releases for biological control of Canada thistle (*Cirsium arvense*) in Ontario, Canada. *Can. Entomol.* 105:1489-1494.
- Smith, A. E. 1973. Transformation of dicamba in Regina heavy clay. *J. Agric. Food Chem.* 21:708-710.
- Smith, A. E. 1973. Degradation of dicamba in prairie soils. *Weed Res.* 13:373-378.

Miscellaneous

- Banting, J. D., and Hay, J. R. 1973. Chemical control of wild oats. Canadex 641.
- Esau, R., and Grover, R. 1973. Chemical weed control in shelterbelts. *Can. Dep. Agric. Publ.* 1511. 10 pp.
- Grover, R., Maybank, J., Yoshida, K., and Plimmer, J. R. 1973. Droplet and volatility drift hazards from pesticide application. *Air Pollut. Control Assoc. Pre-print No.* 73-106, 29 pp.
- Grover, R., Smith, A. E., Khan, S. U., and Emmond, G. S. 1973. Soils and herbicides. Canadex 500.609.
- Harris, P. 1972. Insects in the population dynamics of plants. *In* H. F. van Emden, ed. *Insects/plant relationships*. Symp. R. Soc. London 6:201-209.

Research Station Saskatoon, Saskatchewan

PROFESSIONAL STAFF

J. E. R. GREENSHIELDS, ¹ B.S.A., M.Sc., Ph.D., F.A.I.C.	Director
R. K. DOWNEY, B.S.A., M.Sc., Ph.D.	Assistant Director
J. C. BOYER	Administrative Officer

Scientific Support

F. CHEN (Mrs.), B.A., M.A., M.L.S.	Assistant Librarian
A. E. MCPHERSON (Miss), B.A., B.L.S., M.A.	Library Area Coordinator
H. K. MILNE (Miss)	Computer Systems Programmer
M. E. TAYLOR, B.S.A.	Research Information Officer

Crop Management Section

C. H. KEYS, B.S.A.	Head of Section; Weeds and crop management
W. L. CROWLE, B.S.A., M.Sc.	Cereals and crop management
L. G. SONMOR, B.S.A., M.Sc.	Irrigation
H. UKRAINETZ, B.S.A.	Soil fertility

Plant Breeding Section

R. P. KNOWLES, B.S.A., M.Sc., Ph.D., F.A.I.C.	Head of Section; Grasses
S. J. CAMPBELL, B.Sc., Ph.D.	Oilseed breeding; sunflowers
R. K. DOWNEY, B.S.A., M.Sc., Ph.D.	Oilseed breeding; rapeseed
B. P. GOPLEN, B.S.A., M.Sc., Ph.D.	Legume breeding
R. E. HOWARTH, ² B.S.A., M.Sc., Ph.D.	Legume bloat biochemistry
A. J. KLASSEN, B.S.A., M.Sc., Ph.D.	Oilseed breeding; rapeseed
D. I. MCGREGOR, B.Sc., M.Sc., Ph.D.	Physiology; Brassicas
S. H. PAWLOWSKI, ³ B.Sc., M.Sc.	Oilseed breeding; mustard, sunflowers
G. R. STRINGAM, B.S., M.S., Ph.D.	Cytogenetics; Brassicas

Entomology Section

R. H. BURRAGE, B.S.A., Ph.D.
L. BURGESS, B.Sc., M.Sc., Ph.D.

A. P. ARTHUR, B.Sc., M.S., Ph.D.
R. E. BELLAMY, B.S., M.S., M.A., Ph.D.
N. S. CHURCH, B.Sc., M.S., Ph.D.
C. H. CRAIG, B.A.
G. R. F. DAVIS, B.Sc., M.Sc., Ph.D.
J. F. DOANE, B.S.A., M.Sc., Ph.D.
A. B. EWEN, B.A., M.A., Ph.D.
R. J. FORD, B.S.A., M.Sc., Ph.D.
F. J. H. FREDEEN, B.S.A., M.Sc.
Y. W. LEE, B.S., M.S.
K. S. MCKINLAY, B.Sc.
J. J. R. McLINTOCK, B.Sc., Ph.D.
H. McMAHON, B.S.A., M.Sc.
R. PICKFORD, B.S.A., M.Sc., Ph.D.
L. G. PUTNAM, B.S.A., M.Sc.
J. G. SAHA, B.Sc., M.Sc., Ph.D.
W. W. A. STEWART, B.Sc.
N. D. WESTCOTT, B.Sc., Ph.D.

Head of Section; Wireworms
Associate Head; Oilseed crop
insects
Oilseed crop insects
Mosquitoes
Insect endocrinology
Forage crop insects
Insect nutrition
Wireworms; ecology
Grasshoppers; physiology
Pesticide application; engineering
Black flies
Pesticide chemistry
Pesticide application; toxicology
Mosquitoes and arboviruses
Pollinators
Grasshoppers; ecology
Rapeseed insects
Pesticide chemistry
Mosquito ecology and control
Pesticide chemistry

Plant Pathology Section

R. D. TINLINE, B.A., M.Sc., Ph.D.
S. H. F. CHINN, B.Sc., M.Sc., Ph.D.
H. HARDING, B.Sc., Ph.D.
R. J. LEDINGHAM, B.Sc., M.Sc.
G. A. PETRIE, B.A., M.A., Ph.D.
J. D. SMITH, B.Sc., M.Sc.

Head of Section; Cereal root
diseases
Soil microbiology
Legume and cereal diseases
Cereal root diseases
Oilseed crop diseases
Grass diseases

VISITING SCIENTISTS

National Research Council postdoctorate fellows

H.-C. HUANG, B.Sc., M.Sc., Ph.D., 1972-74

Cereal diseases

S. K. SARKAR, Ph.D., 1973-74

Biochemistry; legume bloat

Colombo Plan graduate student

M. A. SALAM, M.Sc., 1969-73

Oilseed crops

German Academic Exchange Service fellowship

G. RAKOW, Dipl.Agr., Ph.D., 1972-73

Oilseed crops

International Atomic Energy fellow

J. Y. YOO, B.S., 1972-73

Pesticide chemistry

¹On Senior Postdoctoral Research Fellowship, Christchurch, New Zealand, October 1972 to April 1973.

²On transfer of work at Research Station, Summerland, B.C., June 1972 to August 1973.

³On loan to CIDA, August 1973 to May 1974, to take charge of rapeseed development project in Peru.

INTRODUCTION

The Research Station, located on the Saskatoon campus of the University of Saskatchewan, conducts a comprehensive research program on crop production and animal protection. Included are the breeding and management of oilseeds, cereals, grasses, and legumes; ecology and control of some of the most important insect pests, plant diseases, and weeds; and ecology and control of black flies and mosquitoes affecting animals and humans. Research is carried out on the epidemiology of western encephalitis, the histophysiology and nutrition of insects, the fertility and management of soils, pesticide residues in crops and soils, and methods of application of pesticides.

The transfer of the pasture-bloat research program from the Research Station, Summerland, B.C., to this station was completed in September 1973. The objective of the program is to produce a nonbloating alfalfa. Dr. B. P. Goplen will supervise plant breeding and agronomic research, and Dr. R. E. Howarth will be responsible for biochemistry and nutrition research. The cultivars produced will continue to be evaluated for incidence of bloat at the Research Station, Kamloops, B.C.

Accomplishments in selected subjects are summarized in this report. The mailing address of this establishment is Research Station, Research Branch, Agriculture Canada, University Campus, Saskatoon, Sask. S7N 0X2.

J. E. R. Greenshields
Director

CROPS

Oilseeds

New rapeseed varieties and strains. Two new low erucic acid varieties, Midas (*Brassica napus* L.) and Torch (*B. campestris* L.), were licensed in 1973. They were well received by growers and will dominate the plantings in 1974. The first *B. napus* strains that combine low erucic acid oil and low glucosinolate meal with desirable agronomic characteristics were multiplied in the winter of 1972-73, so that commercial evaluation on some 800 contracted ha (2,000 ac) was possible in 1973. The industry-wide program, coordinated from the Station, will permit assessment and documentation of the improved quality and agronomic performance of the SZN71-1788 strain from here, and the S71-940 strain developed at the University of Manitoba.

Improved B. campestris quality. Selection of progeny from interspecific crosses among *B. campestris*, *B. juncea* (L.) Coss., and *B. napus* has resulted in lines of *B. campestris* that produce seed essentially free from erucic acid and glucosinolates. Many of these lines have the additional desirable characteristics of yellow seed coat and good oil and seed yield. A winter increase in 1973-74 will allow limited commercial evaluation in 1974.

Environment and rapeseed quality. Light and temperature during the development of the rape embryo markedly influence seed quality and size. Seed weight, percentage of oil, and degree of unsaturation are positively correlated with day length and negatively correlated with temperature. Percentage protein has shown an inverse relationship.

New seed test for linolenic acid. A simple, rapid, and sensitive test was developed to select half seeds of rape and mustard that are low in linolenic acid. The test, based on the reaction of 2-thiobarbituric acid with the oxidation products of linolenic acid, may also be useful in selection for high or low contents of linolenic acid in other oilseeds such as flax and soybeans.

Dual-purpose yellow mustard. Selection for extreme quantities of erucic acid in commercial population of yellow mustard, *Brassica hirta* Moench or *Sinapis alba* L., has resulted in agronomically acceptable lines with < 2% and > 50% erucic acid. Thus, yellow mustard could be processed to provide either an industrial or an edible oil in addition to its use as a condiment.

Grasses

Breeding grasses for quality. Attempts to breed crested wheatgrass for better quality of hay have shown only limited opportunities

for selection. Quality was determined by in vitro digestibility techniques using sheep-rumen fluid. A five-test comparison of varieties over four seasons showed the following percentages in vitro organic matter digestibility: Fairway 50.5, Parkway 49.9, Nordan 48.4, Summit 48.2, and experimental S-7171, 47.8. Plant selection within the variety Parkway indicated that a 5% improvement in digestibility was possible, with no loss in forage yield.

Comparisons in brome grass showed a very limited range of 0.9% in digestible organic matter for five varieties in several comparative trials.

Brome grass seed midge damage. In 1973, and to a lesser extent in 1972, the brome grass seed midge, *Contarinia bromicola* (Mar. et Ag.), was probably responsible for reducing seed yields of brome grass. This insect destroyed the seed ovary and caused premature seed drop. A survey of 12 seed fields in northeastern Saskatchewan in 1973 showed some fields with only 50% of normal seed set. Burning of trash in fields in early spring appeared to have reduced damage. Although no varietal differences in resistance were found in breeding nurseries, some plants within varieties had negligible damage. Current breeding programs for a full set of seed on plants should automatically result in reduced midge damage.

Breeding for improved hay and seed yields in brome grass. Cooperative progeny tests at the research stations at Saskatoon and Mel-fort showed that limited opportunities exist for breeding varieties with forage yields significantly higher than those of Carlton and Magna. For seed, however, yields 20% above those of Carlton and Magna appear possible concurrent with improved seed-handling quality. Experimental varieties will be formed, aimed at higher forage production, and improved seed quality and yield.

Legumes

Breeding for nonbloating alfalfa. Breeding for nonbloating alfalfa continued with re-sampling of approximately 2,000 plants at Research Station, Summerland, B.C., that were low in total soluble protein (TSP) from the sampling data of 1972. In addition, a further 1,500 plants high in TSP were resampled with the intention of concurrently developing strains both low and high in TSP. The simultaneous development of these

strains should serve as a check on the relative rate and magnitude of the genetic program. A large and diverse accession nursery at the Station was sampled for TSP. A study on the variation and heritability of soluble proteins in alfalfa, completed in 1973, gave relatively high heritability estimates for both TSP and Fraction I. This verifies the feasibility of producing nonbloating alfalfa through plant breeding.

Properties of soluble leaf proteins from alfalfa. Methods for laboratory-scale isolation of alfalfa Fraction II proteins were devised, and selected physical-chemical properties of these proteins were characterized to determine whether they might stabilize rumen foams and cause bloat. Alfalfa Fraction II proteins had isoelectric points in the range of rumen pH. They contained some bound-lipid material and were concentrated in foams. These studies gave preliminary indications that alfalfa Fraction II proteins stabilize rumen foams. Because a correlation between bloat incidence and alfalfa Fraction I (18S) protein was demonstrated previously, it appears that total soluble protein is the factor responsible for bloat in cattle grazing alfalfa pasture.

Alfalfa grown and harvested during hot, dry weather had lower soluble-protein concentration relative to total protein than did alfalfa grown in cooler weather. There were no significant differences in soluble-protein concentrations of alfalfa varieties in general use.

Methods of screening for soluble-protein concentration. The procedure now in use gives soluble-protein concentration of leaves plus stem and requires a two-step extraction. Analyzing leaves alone by a one-step extraction procedure was not satisfactory because it lacked reproducibility.

There was no correlation between soluble-protein concentration in alfalfa and the volume of foam produced by Rumbaugh's foam test. This suggests that in vitro foam volume is determined by some factor or factors besides soluble-protein concentration.

Cereals

Cereals for forage. Cereal variety trials were harvested for forage (early to mid-dough) as well as for grain production in 1973 at seven Project Farms located in northwestern Saskatchewan. Thirty-two varieties and strains were harvested for forage.

Based on the average yields from seven farms, Pitic 62, Bonanza, and Harmon were the top-yielding licensed varieties of wheat, barley, and oats with 6,748, 7,376, and 7,152 kg/ha (3.01-3.29 tons/ac). Analyses for forage quality (in vitro) of specific varieties are being determined. Average forage yields at the Station, 1970-72, for 10 cereal crops harvested as pasture (three to four cuts each year), hay (anthesis plus aftermath), early to mid-dough, and seed (grain plus straw) stages were 3,341, 6,322, 7,757, and 10,739 kg dry matter/ha (1.49-4.79 tons/ac). The average protein contents for the four stages involved, based on 1971 data, were 25.36%, 13.12%, 7.94%, and 4.54%, respectively. In terms of yields of digestible organic matter in vitro, wheats such as Pitic 62 appear more promising than the oat and barley varieties tested. In conjunction with this research, animal feeding trials (in vivo) involving 7 cereal crops, 16 silos, and Hereford steers were undertaken in 1973 at the University of Saskatchewan.

Irrigation

Irrigated crops. Crop-sequence trials conducted on five annual crops following perennial crops over a period of 5 yr were completed. A grass-alfalfa forage hay crop in an irrigated rotation provided greater returns to succeeding crops than when grass crops were grown by themselves. The 4-yr average amount of mineralized N varied from only 56 kg/ha (50 lb/ac) after plow down of grasses to 95 kg/ha (85 lb/ac) with grass-alfalfa mixtures, and up to 118 kg/ha (105 lb/ac) from pure alfalfa stands. This can result in considerable savings of applied fertilizers over a period of time. Bromegrass and crested wheatgrass (particularly without alfalfa) tended to lower the yields of succeeding crops to a greater degree than either intermediate wheatgrass or reed canarygrass. Wide variations in N and P requirements were found in the experiments just concluded. It seems necessary to use a soil test to determine fertilizer recommendations for any crop following any other forage or annual crop grown in a particular sequence.

PLANT DISEASES

Common Root Rot of Cereals

The severity of common root rot appeared higher in 1973 than in recent years. Estimates of loss obtained by comparing yields of healthy and diseased plants in samples from selected survey fields were 12.5% in common wheat, 15.0% in durum wheat, and 13.9% in barley. Because diseased plants were intermixed with healthy ones in the field, the individual-plant method may tend to exaggerate loss. Various approaches to ascertain the importance of interplant competition in loss appraisal have not given unequivocal results. Replicated field experiments frequently failed to indicate that increased plant competition maximized yield reduction from disease. Greenhouse tests, however, showed that yield compensation occurred in uninoculated plants competing with inoculated ones within the same container. Furthermore, analysis of survey data during the period 1969-71 suggested that compensation was most pronounced when a few clean plants were competing with several diseased ones. The reduction in yield per diseased plant was higher in survey fields of high disease intensity than in those of low disease intensity.

Reduced sporulation of *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur, the main incitant of common root rot, on infected subterranean plant parts was associated with the application of certain fungicidal sprays to basal parts of wheat plants. Various fungicides applied as seed treatments had no appreciable effect on the severity of the disease in ripening plants. Under greenhouse conditions, *Aureobasidium pullulans* (de Bary) Arn. and two *Fusarium* spp. appeared able to invade subcrown internodes of wheat plants and to reduce attack of the tissue by *C. sativus*.

Isolates of *C. sativus* differed in aggressiveness to wheat cultivars, but virulence races were not found that attacked cultivars differentially.

Numerous lines of barley and wheat were screened in the field for resistance to common root rot. A number of lines exhibited levels of resistance equal to or better than the most resistant of commercial varieties. These and other selections will undergo extensive testing in 1974.

Diseases of Grasses

In laboratory tests, a few selections of creeping red fescue appeared resistant to stem eyespot caused by *Didymella festucae* (Weg.) Holm. Stem eyespot is a serious problem in seed crops of red fescue in the Peace River area of Alberta and British Columbia.

A low-temperature fungus with orange rindless sclerotia was very prevalent on alfalfa and alsike clover and widespread in snow-mold patches on turfgrass in Saskatchewan and Alberta. The fungus denoted as ORS is unnamed but is possibly a *Tubercularia* sp. In laboratory cultures at low temperatures, it was antagonistic to the growth of several other snow-mold pathogens.

Diseases of Alfalfa

The survey of alfalfa diseases was continued. The incidence of yellow leaf blotch, *Leptotrochila medicaginis* (Fckl.) Schüepp, was low, although severe infections developed later in the season at the Station. Among 300 accessions of *Medicago sativa* L. and *M. falcata* L. being screened for disease resistance, 15 *M. falcata* lines from the USSR were remarkably free from all foliage diseases.

Diseases of Oilseeds

White rust, caused by *Albugo cruciferarum* S.F. Gray, is an important disease of turnip rape, *B. campestris*, in Western Canada. Apparently, the pathogen overwinters as thick-walled oospores in infected tissue. Attempts by various investigators over many years to germinate spores of this type have generally met with little success. Recently, a simple method was found that promotes a high percentage germination of oospores from material 2 wk to several years old. This discovery should facilitate the development of control methods, particularly the use of genetic resistance.

Additional sources of resistance to white rust have been identified in collections of *B. campestris* from Mexico and Costa Rica.

ENTOMOLOGY

Rapeseed Insects

Bertha armyworm. Approximately 75% of the bertha armyworms that were reared on the best modification of the Sutter and Miller

diet for cutworms pupated successfully. Pupae reared on this diet were about one-third larger than those reared on living plants, and resulting moths deposited about three times as many eggs.

Oviposition studies in the laboratory showed that females of the bertha armyworm exposed to plants of rape, flax, and lamb's-quarters preferred to oviposit on lamb's-quarters. Chemical extracts were made from lamb's-quarters, but female moths have not yet oviposited on or near these extracts. To test the effect of this preference in the field, borders of lamb's-quarters were planted as a trap crop around plots of rape. Egg and larval samples from the rape and lamb's-quarters did not show a concentration of the bertha armyworm population in the lamb's-quarters, indicating that it was not an effective trap crop under the test conditions.

Laboratory studies of *Banchus* sp., a hymenopterous parasite, showed that females will deposit eggs in the first three larval instars of the bertha armyworm. At $21.7 \pm 0.6^\circ\text{C}$ the egg hatches in approximately 60 h. The parasite continues development to its second instar and then does not molt again, although it may increase considerably in size, until the host larva enters the ground to pupate. The host larva may not enter the ground for up to 22 days after parasitization. After the host pupa has formed the earthen cell, the parasite resumes development and passes through the next three instars in 4 to 6 days. The host then dies, and the mature parasite larva forms its own cocoon within the host cell.

A simple field experiment was set up to investigate the effect of the age of the food plant (*B. napus* cultivar Zephyr) on the bertha armyworm introduced into the field just after hatching. Variations in plant development were obtained by early, intermediate, and late dates of seeding. At the time of populating the caged plots, the oldest plants had almost finished blooming and had dropped their broad leaves, leaving only lanceolate leaves. The youngest plants were blooming actively and their foliage was in a succulent condition; only a few of the lower leaves had begun to wilt. Twenty percent of the larvae on the oldest plants survived and all failed to form pupae. On the late-sown plots, survival was 40% and normal pupation proceeded. Suitable synchronization of hatching and food-plant development is

therefore important to the bertha armyworm. Maturing caterpillars can attack maturing silicles, but immature larvae appear to need succulent foliage for development.

Low populations of overwintering pupae and low light-trap catches of the bertha armyworm in Saskatchewan effectively predicted reduced levels of larval infestation, and very few fields of rape required chemical control in 1973.

Flea beetles. Adults of five species of flea beetles were found attacking rape crops in the Prairie Provinces; these species were identified as *Phyllotreta cruciferae* (Goeze), *Psylliodes punctulata* Melsh., *Phyllotreta striolata* (F.), *Phyllotreta robusta* Lec., and *Phyllotreta albionica* (Lec.). Of these, *P. cruciferae* is generally the most abundant and serious pest of rape, followed in order by *P. punctulata* and *P. striolata*. *P. robusta* and *P. albionica* are present in only small numbers and they have not proved to be serious pests. *Disonycha triangularis* (Say), a large and conspicuous flea beetle, was collected from rape fields, but it has not been observed feeding on rape.

Rape crops in the seedling stage are particularly susceptible to flea-beetle damage, but occasionally in late summer, green, semimature plants are intensively attacked by newly emerged beetles that quickly devour the epidermis from stems, pods, and leaves. Well-ripened crops usually receive little damage. Flea beetles show an apparent preference for rape plants whose foliage is exposed to bright sunlight, such as seedlings, isolated plants, or plants in widely spaced rows. Shade, such as exists in a dense stand of rape beyond the prebloom stage, appears to inhibit attack.

P. cruciferae appears to confine its feeding activity largely to cruciferous plants, whereas *P. punctulata* also feeds extensively on wild buckwheat and sometimes on lamb's-quarters. Stinkweed, although a crucifer, is rarely attacked by flea beetles if other food plants are present. A preference for feeding on wild mustard rather than the *B. campestris* type of rape was observed for *P. cruciferae* in the field. Seedlings of two species of peppergrass are a source of food for flea beetles in the early spring.

Wireworms

Feeding activity. The corpora allata, the source of juvenile hormone in insects, were shown to be involved in the regulation of feeding activity in larvae of *Ctenicera destructor* (Brown). Their role, however, is contributory rather than determinative. Larvae that had been kept 4 mo at 7°C were treated with moderate doses of synthetic juvenile hormone and fed and reared individually. The treatment intensified and advanced the commencement of the first cycle of feeding and tended to advance the molt that followed. Repeated treatment, upon cessation of feeding after several feeding and molting cycles, had little or no effect. Once feeding responses were firmly turned off, the larvae were quite refractory to the hormone treatment.

Orientation behavior. Although *Agriotes obscurus* (L.) larvae that were collected in autumn did not orientate to a pointlike heat source, similar work with *C. destructor* showed that a response to heat occurs with this species and led to the following conclusions. *C. destructor* larvae do not move to the soil surface in the spring in response to warming of the surface soil; orientation to a heat source along a temperature gradient occurs after larvae become acclimatized to a certain temperature and are then subjected to a lower temperature; the best response occurs when the difference between the adaptation temperature and the test temperature is 5.5–9°C; and the mechanism of the response to heat is definitely a thermotaxis. Larvae are highly sensitive to very small temperature gradients.

Prestarved *C. destructor* larvae responded continuously to CO₂ during a feeding cycle. Larvae oriented to a CO₂ source before and after feeding had commenced and throughout the active feeding period; however, there were indications that the response threshold changed during a cycle. After feeding had tapered off, the CO₂ response declined.

Grasshoppers

Reproduction. Males of the clear-winged grasshopper produce and deposit a single spermatophore, which is placed deep within the female. However, part of the spermatophore seems to be retained in the ejaculatory duct of the male. Thus, in pairs that have copulated for long enough periods of time,

serial sections show the spermatophore as a bulbous structure within the male from which protrudes a long, thin, simple tube that becomes highly coiled as it penetrates deep within the spermatheca of the female. It is therefore likely that sperm bundles are deposited in or near the preapical diverticulum of the female, unlike in *Melanoplus* spp. where they are deposited near the proximal end of the spermathecal duct.

Juvenile hormone analogues. Fifteen analogues of insect juvenile hormone were tested as ovicidal agents against eggs of the migratory grasshopper, *M. sanguinipes* (Fabr.), that were < 3 h, 1, 3, 6, and 11 days old. Six of these compounds prevented or drastically reduced hatch at doses as low as 0.001 μ g per egg, even when applied to eggs that were almost fully developed (11 days old). They seemed equally effective when applied to very young eggs (up to 1 day old) at these or lower concentrations, but were less effective on 3- or 6-day-old eggs.

Embryonic development and water uptake. Studies on the relationship of water intake and embryonic development of clear-winged grasshopper eggs in the field and laboratory showed substantial differences from the situation reported in *Melanoplus*. With the clear-winged grasshopper the relationship may be generally outlined as follows: at the time of oviposition the average weight of eggs is 3.8 mg and they absorb no water during the first 3 wk or so while the early stages of embryonic growth take place. If moisture is available during late summer, the eggs gradually take in a small amount of water and reach a weight of about 4.5 mg by freeze-up. At this time most eggs enter diapause at the preblastokinesis stage. During the winter, eggs lose little or no weight. Early the next spring after the snow cover melts, but when temperatures are relatively low, water is rapidly taken into the eggs (average weights increase to 6.6 mg by March 26, to 7.1 mg by April 10, and to 8.1 mg by April 25). During this time, no apparent development of the embryos occurs. By May 2, most embryos have begun the process of blastokinesis and hatch about mid-June; at the same time little further water is taken into the eggs. Eggs brought into the laboratory during the winter and incubated at 30°C show a somewhat different pattern as embryonic development and water

intake take place at the same time, shortly after incubation begins.

The significance of these findings is that water intake occurs when moisture is most likely available so that development may proceed early in the spring as soon as temperatures are high enough, thereby permitting an early hatch.

Forage Insects

Alfalfa leafcutter bee, *Megachile rotundata* (F.). A strain of bees has been selected over the past 8 yr by holding prepupae at 24.4°C for at least 6 wk in the fall, discarding adults that emerge, and thus gradually eliminating bees with less intense diapause. In 1972 and 1973, an estimated 20% of the selected strain with the more intense diapause foraged during unfavorable weather when no foraging was done by third- and fourth-generation bees of imported stock from Idaho. Although multiplication of the selected strain of bees appeared slightly greater than normal under unfavorable weather conditions in 1972, it appeared slightly less in 1973 under generally favorable weather conditions.

Mosquitoes

Abundance. In 1972 in southern Saskatchewan, mosquitoes were much less abundant than in 1971 and their numbers were well below the long-term averages. In 1973, numbers increased at Saskatoon about 300%, and at Outlook about 15% over 1972 levels, but were still well below those of 1971 and the long-term averages. At Weyburn, mosquito populations in 1973 were about 20% of the numbers in 1972. This decrease in abundance from north to south was typical of the mosquito population dynamics in 1973 in Saskatchewan and perhaps in Alberta also. However, Alberta experienced one of the worst mosquito outbreaks in a band stretching east from the foothills between Calgary and Edmonton, with the heaviest infestation in the Looma-Provost-Hanna area. This outbreak extended eastward, apparently with diminishing intensity, to the St. Walburg and Prince Albert areas of Saskatchewan. The species composition of the outbreak in Alberta is not yet known, but in Saskatchewan the predominant species throughout June and July were *Aedes cataphylla* Dyar and *A. fitchii* (Felt & Young); *Culiseta inornata* (Will.) increased during the latter half of

June and continued at a high level until the end of the third week of August. The abundance of *Culex tarsalis* Coq., the principal mosquito vector of the western equine encephalomyelitis (WEE) virus and probably also of some other arboviruses in Saskatchewan, has steadily decreased since 1971. In 1973, the population levels of *C. tarsalis* were very close to those of 1968, the year with the smallest *C. tarsalis* populations in 10 yr. Mosquito-population data over a period of 10 yr indicate that, although mosquitoes are probably not more abundant in one area of the province than in another, *C. tarsalis* is more abundant in southeastern Saskatchewan than anywhere else in the province. WEE is believed to be endemic in southeastern Saskatchewan.

Arboviruses in Saskatchewan and the Northwest Territories. In recent years, increased use of suckling mice as the host system for primary isolation attempts has revealed the presence in Saskatchewan of at least seven mosquito-borne arboviruses in addition to that of WEE. As mentioned in a previous report, the Hart Park-Flanders virus is widely distributed in Saskatchewan. It has been isolated from the mosquitoes *C. tarsalis*, *A. vexans* (Mg.), and *A. spencerii* (Theo.), and apparently is a late-season virus in that it has been isolated only from July 30 to September 1. The Turlock virus was isolated from *C. tarsalis* collected at Aberdeen and Outlook and only in August; apparently it is another late virus. The Cache Valley virus was isolated from *C. inornata* taken at Saskatoon and Weyburn and again only in August. The first isolation of the St. Louis encephalitis virus in Canada was made from *C. tarsalis* taken at Weyburn on August 27, 1971, but it is not known if that isolation represents a long-standing endemicity or a recent expansion of the range of the St. Louis encephalitis virus. Some viruses of the California encephalitis (CE) group were isolated from *Aedes* mosquitoes (at least four species) taken in the St. Walburg and Prince Albert areas of Saskatchewan. Isolation of one CE virus from the blood of a sentinel rabbit in the Saskatoon area gave the present known southern limit of its distribution in Saskatchewan. Another virus, at present unknown and tentatively labeled WMC-152-71, was isolated from *C. tarsalis* taken at Weyburn on July 12 and 21. About 20 to 30 virus strains isolated from Saskatchewan mosquitoes have

not been identified. During the summer of 1973, a total of 6,754 living mosquitoes representing four or five species from Rankin Inlet, NWT, yielded four isolations of a CE virus from 4,547 specimens of the *A. punctator-hexodontus* complex. These isolations indicate a remarkably wide geographic distribution of the CE virus group, which encompasses tundra, mixed-wood forest, and aspen parkland. In tundra and mixed-wood forest the virus is carried by boreal *Aedes*, whereas the vector in aspen parkland of Saskatchewan is still unknown.

Pesticide Application

A method for controlling droplet size to reduce spray drift was designed; it is less expensive and less complex for field use than the spinning disc developed here previously. This new method uses ordinary hydraulic-spray nozzles; most of the smaller droplets that cause drift are removed by a simple air curtain and trap arrangement. A still less expensive and complex method using a gauze shroud over the spray boom is being investigated; this is less effective than the more sophisticated systems, but it still reduces drift by 80%.

Pesticide Chemistry

Methodology. A method was improved for the determination of residues of technical chlordane in soils and plants. The gas chromatogram of technical chlordane gives about 14 peaks and does not cleanly separate the main peaks. A new column was made to separate cleanly the main peaks in technical chlordane and to improve its determination in soils and plants.

Translocation and retention. Studies were carried out on absorption of technical chlordane by carrots, potatoes, wheat, alfalfa, and peas grown in soil treated with the toxicant at 11.2 kg/ha (10 lb/ac). It was shown that carrots had a residue level of 2.3 ppm of technical chlordane, whereas potatoes, wheat, alfalfa, and peas contained 0.01-0.12 ppm. Carrot peels had the highest residue levels (7.6-10.0 ppm), whereas carrot pulp absorbed very little of the toxicant (up to 0.08 ppm).

Metabolism. Work was completed on the isolation and identification of organic solvent-soluble metabolites of lindane-¹⁴C-treated wheat stored for 80 days. One main metabolite was isolated and identified by gas

chromatography and gas chromatography – mass spectrometry; this was α -pentachlorocyclohexene, which accounted for 1.23% of the total lindane- ^{14}C applied.

Pollution potential. The possibility of the contamination of game birds with seed-treatment fungicides, which have replaced mercury compounds, was studied with Vitavax- ^{14}C (UniRoyal Ltd.) (aniline ring – U.L.- ^{14}C). Pheasants were fed analytical grade Vitavax- ^{14}C in gelatin capsules. It was found that the pheasants excreted about 60% of the total administered Vitavax in 72 h after feeding and about 73% within 7 days. Eight major metabolites were found; two were

isolated by thin-layer chromatography and identified by mass spectrometry as Vitavax-sulfoxide and Vitavax-sulfone.

Insect Nutrition

Comparative dietary studies using yellow mealworm larvae showed close agreement between classification of protein quality by these larvae and classification by mice and rats. The yellow mealworm method of evaluation seems to be particularly useful when only small amounts of test protein are available. Preliminary investigations indicated that this insect may be useful also as a bioassay agent for isothiocyanates in rapeseed and mustard seed.

PUBLICATIONS

Research

- Arthur, A. P., and Smith, B. C. 1973. *Thymelicus lineola*: Effects of mowing and silica sprays on populations. J. Econ. Entomol. 66:907-908.
- Bailey, D. A., Bell, R. D., and Howarth, R. E. 1973. The effect of exercise on DNA and protein synthesis in skeletal muscle of growing rats. Growth 37:323-331.
- Burgess, L. 1973. Axon pathways of the intermediate neurosecretory cells in *Culex tarsalis* Coquillett (Diptera: Culicidae). Can. J. Zool. 51:379-382.
- Chinn, S. H. F. 1973. Effect of eight fungicides on microbial activities in soil as measured by a bioassay method. Can. J. Microbiol. 19:771-777.
- Church, N. S. 1973. Prairie grasshoppers in 1876. Bull. Entomol. Soc. Can. 5:79.
- Davis, G. R. F. 1972. Application of insect nutrition in solving general nutrition problems. Pages 33-39 in J. G. Rodriguez, ed. Insect and mite nutrition. North Holland, Amsterdam.
- Davis, G. R. F. 1972. Refining diets for optimal performance. Pages 171-181 in J. G. Rodriguez, ed. Insect and mite nutrition. North Holland, Amsterdam.
- Davis, G. R. F. 1973. Quantitative dietary requirements of the saw-toothed grain beetle, *Oryzaephilus surinamensis*, for L-leucine. J. Insect Physiol. 19:273-276.
- Davis, G. R. F. 1973. Quantitative requirements of the saw-toothed grain beetle, *Oryzaephilus surinamensis*, for dietary L-isoleucine and L-valine. J. Insect Physiol. 19:1657-1661.
- Davis, G. R. F., and Sosulski, F. W. 1973. Improvement of basic diet for use in determining the nutritional value of proteins with larvae of *Tenebrio molitor* (L.). Arch. Int. Physiol. Biochim. 81:495-500.
- Doane, J. F., Klingler, J., and Welch, H. E. 1972. Parasitism of *Agriotes obscurus* Linnaeus (Coleoptera: Elateridae) by *Hexameris* sp. (Nematoda: Mermithidae). Mitt. Schweiz. Entomol. Ges. 45:299-300.
- Finlayson, A. J., Krzymanski, J., and Downey, R. K. 1973. Comparison of chemical and agronomic characteristics of two *Brassica napus* L. cultivars, Bronowski and Target. J. Am. Oil Chem. Soc. 50:407-410.
- Gerber, G. H., and Church, N. S. 1973. Courtship and copulation in *Lytta nuttallii* (Coleoptera: Meloidae). Can. Entomol. 105:719-724.
- Harding, H. 1972. Foliage diseases of alfalfa in northern Saskatchewan; a note on the 1972 survey and the differential reactions of nine varieties. Can. Plant Dis. Surv. 52:149-150.
- Harding, H., and Morrall, R. A. A. 1973. First record of *Gymnosporangium clavipes* on *Malus* sp. in Western Canada. Can. Plant Dis. Surv. 53:60.
- Hegdekar, B. M., and Arthur, A. P. 1973. Host hemolymph chemicals that induce oviposition in the parasite *Itopectis conquisitor* (Hymenoptera: Ichneumonidae). Can. Entomol. 105:787-793.
- Howarth, R. E., McArthur, J. M., Hikichi, M., and Sarkar, S. K. 1973. Bloat investigations; denaturation of alfalfa fraction II proteins by foaming. Can. J. Anim. Sci. 53:439-443.

- Howarth, R. E., McArthur, J. M., and Goplen, B. P. 1973. Bloat investigations: Determination of soluble protein concentration in alfalfa. *Crop Sci.* 13:677-680.
- Iversen, J. O., Wagner, R. J., de Jong, C., and McLintock, J. 1973. California encephalitis virus in Saskatchewan: Isolation from boreal *Aedes* mosquitoes. *Can. J. Public Health* 64:590-594.
- Kagawa, T., McGregor, D. I., and Beevers, H. 1973. Development of enzymes in the cotyledons of watermelon seedlings. *Plant Physiol.* 51:66-71.
- Karapally, J. C., Saha, J. G., and Lee, Y. W. 1973. Metabolism of lindane-¹⁴C in the rabbit: Ether-soluble urinary metabolites. *J. Agric. Food Chem.* 21:811-818.
- McKinlay, K. S., Ford, R. J., and Martin, W. K. 1973. A means of winnowing hydraulic nozzles to control droplet drift. *Can. Agric. Eng.* 15:24-25.
- Mukerji, M. K. 1973. The development of sampling techniques for populations of the tarnished plant bug, *Lygus lineolaris* (Hemiptera: Miridae). *Res. Popul. Ecol.* 15:50-63.
- Petrie, G. A. 1973. Diseases of *Brassica* species in Saskatchewan, 1970-72. I. Staghead and aster yellows. *Can. Plant Dis. Surv.* 53:19-25.
- Petrie, G. A. 1973. Diseases of *Brassica* species in Saskatchewan, 1970-72. II. Stem, pod and leaf spots. *Can. Plant Dis. Surv.* 53:83-87.
- Petrie, G. A. 1973. Diseases of *Brassica* species in Saskatchewan, 1970-72. III. Stem and root rots. *Can. Plant Dis. Surv.* 53:88-92.
- Petrie, G. A. 1973. Herbicide damage and infection of rape by the blackleg fungus, *Leptosphaeria maculans*. *Can. Plant Dis. Surv.* 53:26-28.
- Pickford, R., and Padgham, D. E. 1973. Spermatophore formation and sperm transfer in the desert locust, *Schistocerca gregaria* (Orthoptera: Acrididae). *Can. Entomol.* 105:613-618.
- Pirozynski, K. A., and Smith, J. D. 1972. A *Septoria* disease of *Koeleria macrantha* in Alberta and Saskatchewan. *Can. Plant Dis. Surv.* 52:153-155.
- Putnam, L. G. 1973. Effects of the larval parasites *Diadegma insularis* and *Microplitis plutellae* on the abundance of the diamondback moth in Saskatchewan rape and mustard crops. *Can. J. Plant Sci.* 53:911-914.
- Rakow, G., and McGregor, D. I. 1973. Opportunities and problems in modification of levels of rapeseed C₁₈ unsaturated fatty acids. *J. Am. Oil Chem. Soc.* 50:400-403.
- Saha, J. G., Burrage, R. H., Nielsen, M. A., and Sumner, A. K. 1973. Chlordane residues in potatoes grown in treated soil and their reduction by home processing. *J. Econ. Entomol.* 66:1125-1127.
- Saha, M., Sumner, A. K., and Saha, J. G. 1973. Comparison of three extraction and cleanup methods for determining carbon-14-labeled residues from wheat plants grown in soil treated with Dyfonate-ring-¹⁴C. *J. Assoc. Off. Anal. Chem.* 56:45-48.
- Salam, M. A., and Downey, R. K. 1973. Selectivity of benazolin in Cruciferae. *Can. J. Plant Sci.* 53:891-896.
- Smith, J. D. 1972. *Marasmius* fairy rings: Lawn age and incidence. *J. Sports Turf Res. Inst.* 48:24.
- Smith, J. D., and Knowles, R. P. 1973. Resistance to *Pyrenophora bromi* in bromegrass. *Can. J. Plant Sci.* 53:93-99.
- Stewart, W. W. A. 1973. Seasonal occurrence and species composition of mosquito adults and larvae in a fresh water breeding site near Saskatoon, Saskatchewan. *Mosq. News* 33:545-553.
- Stringam, G. R. 1973. Inheritance and allelic relationships of seven chlorophyll-deficient mutants in *Brassica campestris* L. *Can. J. Genet. & Cytol.* 15:335-339.
- Stringam, G. R., and Downey, R. K. 1973. Haploid frequencies in *Brassica napus*. *Can. J. Plant Sci.* 53:229-231.
- Sumner, A. K., Saha, M., and Saha, J. G. 1972. Extraction of residues of Dyfonate-ring-¹⁴C from soil. *Int. J. Environ. Anal. Chem.* 2:139-148.

Miscellaneous

- Craig, C. H. 1973. Insect pests of legume and grass crops in Western Canada. *Can. Dep. Agric. Publ.* 1435, rev. 27 pp.
- Davis, G. R. F. 1973. Good protein? Ask the yellow mealworm. *Can. Agric.* 18(4):22-23.
- Fredeen, F. J. H. 1973. Black flies. *Can. Dep. Agric. Publ.* 1499. 19 pp.
- Goplen, B. P., Cooke, D. A., and Pankiw, P. 1973. Isolation distances required for sweetclover seed production. *Can. Agric.* 18(3):13-14.
- Goplen, B. P., Cooke, D. A., and Pankiw, P. 1973. Isolation distances for sweetclover seed production. *Canadex* 123.15.
- Knowles, R. P. 1973. Bromegrass seed midge. *Canadex* 127.622.

- McKinlay, K. S., and Dolezsar, F. L. 1973. The effects of spray characteristics on the toxicity of herbicides. *Can. Agric.* 18(4):6-9.
- Saha, J. G. 1973. Biting fly control and environmental quality. *Proc. Symp. Univ. Alta., Edmonton, Def. Res. Board, Ottawa.* pp. 19-34.
- Smith, J. D. 1973. Overwintering diseases of turfgrasses in Western Canada. *Proc. Joint Northwest Turfgrass Assoc. Can. Turfgrass Assoc. Conf., Harrison Hot Springs, B.C.* pp. 96-103.
- Tinline, R. D., Ledingham, R. J., Petrie, A., Harding, H., and Smith, J. D. 1972. Plant diseases. Pages 290-291 *in* 67th Annu. Rep. Sask. Dep. Agric.

Research Station Swift Current, Saskatchewan

PROFESSIONAL STAFF

A. A. GUITARD, B.Sc., M.Sc., Ph.D.
G. E. KERLEY, C.D.

Director
Administrative Officer

Information

A. K. LAIRD (Mrs.)
P. I. MYHR, B.S.A.

Librarian
Research Information

Cereal Production and Utilization

C. H. ANDERSON, B.Sc., M.Sc.

W. DEDIO, B.Sc., M.Sc., Ph.D.
M. E. DODDS, M.B.E., C.D., B.E.
K. E. DUNKELGOD, B.S., M.S., Ph.D.
D. G. GREEN, B.S.A., M.S., Ph.D.
E. A. HURD, B.S.A., M.Sc., Ph.D.
D. S. McBEAN, B.S.A., M.Sc.
D. W. L. READ, B.S.A., M.Sc.
R. E. SALMON, B.S.A., M.S.A., Ph.D.
T. F. TOWNLEY-SMITH, B.S.A., M.Sc., Ph.D.
L. M. WRIGHT, B.Sc., M.Sc.

Head of Section; Cultural
management
Durum wheat breeding
Harvesting
Turkey nutrition
Hardiness physiology
Spring wheat breeding
Rye breeding
Fertility management
Turkey nutrition
Durum wheat breeding
Cereal harvesting

Forage Production and Utilization

D. H. HEINRICHS, B.S.A., M.Sc., Ph.D., F.A.I.C.
M. R. KILCHER, B.S.A.
H. C. KORVEN, B.E., M.Sc.
T. LAWRENCE, B.S.A., M.Sc., Ph.D.
J. LOOMAN, B.Sc., M.Sc., Ph.D.
J. D. McELGUNN, B.S., M.Sc., Ph.D.

Head of Section; Legume breeding
Forage management
Irrigation management
Grass breeding
Range ecology
Production physiology

Environment

W. L. PELTON, B.S.A., M.S.A., Ph.D.	Head of Section; Agrometeorology
V. O. BIEDERBECK, B.S.A., M.Sc., Ph.D.	Soil microbiology
F. BISAL, B.S., M.S.	Soil physics
C. A. CAMPBELL, B.S.A., M.S.A., Ph.D.	Soil chemistry
W. NICHOLAICHUK, B.E., M.Sc.	Hydrology
D. W. STEWART, B.S.A., M.Sc., Ph.D.	Environmental physiology

Analytical Services and Design

F. G. WARDER, B.S.A., M.Sc.	Head of Section; Soil chemistry
F. B. DYCK, B.E., M.Sc.	Equipment design
W. C. HINMAN, B.Sc., M.Sc.	Soil chemistry
H. MOEN	Computer programmer

Departures

R. W. LODGE, B.S.A., M.Sc., Ph.D. Transferred to PFRA, Regina, Sask., May 15, 1973	Pasture management
G. W. ROBERTSON, B.Sc., M.A. Retired August 31, 1973	Head of Section; Climate
J. L. THOMPSON, B.E., M.E. Retired August 31, 1973	Head of Section; Threshing equipment

VISITING SCIENTISTS

All-India Dryland Program

D. P. KATARIA, B.Sc. (Eng.)	Equipment design
G. P. VERMA, B.Sc., M.Sc., Ph.D.	Soil chemistry
K. VIJAYALAKSHMI, B.Sc., M.Sc., Ph.D.	Soil physics

INTRODUCTION

The climate of southwestern Saskatchewan is characterized by low precipitation, high evaporation, and wide extremes in temperature. Throughout the region, cereal grains are grown on a variety of soils, and cattle are raised on natural and cultivated grasslands. Small areas are irrigated. Research is focused on improving the economy and stability of this production.

Climatically, 1973 was most unusual. Moisture reserves were critically low until April, when 7.3 cm of precipitation restored soil moisture to slightly above normal. This near-record April precipitation was followed by only 5 cm of precipitation during May, June, and July, the lowest precipitation ever recorded during the growing season at Swift Current. The effects of this low precipitation were offset by cool growing conditions early in the season, excellent soil moisture at time of seeding, and favorable temperatures during July. The result was only a moderate reduction in the yield of wheat, but a severe reduction in the yield of forage.

Good progress was made in a number of areas of research. A new variety of durum wheat developed by Dr. T. F. Townley-Smith and Dr. E. A. Hurd will be licensed and named "Macoun." It has the Wakooma quality desired by certain of our international markets and is slightly higher yielding.

Before retiring at the end of August, Mr. G. W. Robertson developed a mathematical model in which variation in weather accounts for 73% of the annual variation in the yield of wheat. The model can be used for predicting the yield of wheat.

These and other research accomplishments are described briefly in this report. Detailed information can be obtained from the publications listed at the end of the report, from Mr. P. I. Myhr, or from the individual scientists. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Sask. S9H 3X2.

A. A. Guitard
Director

CEREAL CROPS

Breeding and Evaluation

Yield test efficiency. The relative efficiency of repeated control plots and moving mean adjustments was compared for measuring yield in large replicated yield trials. With but few exceptions, the optimum adjustment obtained by using the moving mean of adjacent plots gave greater reduction in error than the use of covariance or control plots. The optimum number of adjacent plots used to develop the moving mean varied widely from test to test. Because of this, plant breeders who wish to use this method will have to conduct analyses to obtain the most accurate adjustment for their specific conditions.

Macoun durum wheat. This new durum variety will be licensed early in 1974 and 43,000 kg of seed distributed to growers in Alberta, Saskatchewan, and Manitoba. Macoun is expected to replace Hercules on the eastern prairies, and on the western prairies it will compete with Wascana, which now

occupies 26% of the durum acreage in Western Canada. If Macoun replaces the older durum varieties, Stewart, Pelissier, and Ramsey, the quality of Canadian durum will be very much improved.

Macoun was selected at the research stations at Regina and Swift Current from a cross between two sister lines of Hercules made at the Research Station at Winnipeg, in 1964. It is shorter than Wascana, is stronger strawed, is earlier maturing, has higher bushel weight, and is equal in disease resistance. It yields slightly more than Wascana in the Black soil zone and is about equal in the Brown. Macoun is superior to Wascana in quality and fully equal to Wakooma.

Amino acid levels in wheat. The amino acid values of 49 cultivars of utility and bread wheats, expressed as grams per 16 g of N, varied from 2.6 to 4.0 for cystine, 5.1 to 7.1 for arginine, 2.2 to 2.9 for threonine, 3.0 to 4.0 for isoleucine, 6.4 to 7.6 for leucine, 3.6 to 4.6 for valine, and from 4.2 to 5.4 for

phenylalanine. Satisfactory amino acid balances for turkeys were found in both high- and low-protein cultivars.

In another study, where poults were fed diets based on five different cultivars of wheat with varying protein levels, amino acid balance had a greater influence than protein level on growth rate.

Management of Sunflowers

Preseeding cultivation. Sunflowers grown in 36-cm spaced rows on summerfallow yielded 803 kg/ha after preseeding tillage compared with 734 kg/ha when direct seeded. With the addition of N at 5 kg/ha and P at 22 kg/ha, the yields were 862 and 813 kg/ha respectively. When grown in 18-cm spaced rows, the unfertilized stands yielded 578 kg/ha when tilled before seeding and 611 kg/ha when seeded directly into untilled soil. When fertilized, the corresponding values were 585 and 518 kg/ha respectively. Under similar conditions, unfertilized wheat yielded 1,473 kg/ha when the soil was tilled before seeding and 1,513 kg/ha when no preseeding tillage was provided.

Effects of population and row spacing. Higher yields were obtained from populations of 25,000 plants/ha than from populations of 75,000 or 125,000 plants/ha. Plants in the low population had the greatest number of leaves, thicker stems, a higher concentration of N in the stalk, leaf, and head, and the heaviest seeds. Most important, the lower population utilized moisture most efficiently, especially when the rows were widely spaced. This appears to be due not only to the aboveground geometry but also to the fact that with the low populations a greater portion of the root penetrated deep into the soil.

Requirement for phosphorus. In a growth-room experiment, dry matter production was greater for sunflowers than for wheat but the P content of the tissue was lower, so that the total amount of P in the harvested tissue was similar for the two crops. The amounts of P derived from the fertilizer and from the soil were also similar for the two crops. Dry matter production, P content of the tissue, and uptake of soil P by sunflowers were not influenced by placement of fertilizer. The crop absorbed the most fertilizer P when the fertilizer was placed at seed level and the least when it was mixed with the soil. Because sunflowers and wheat are similar in

their uptake of soil and fertilizer P, rate of application and depth of placement of fertilizer P for sunflowers grown in southwestern Saskatchewan should be the same as for wheat.

Cold Tolerance in Winter Wheat

Oligosaccharide patterns for the hardy Kharkov MC22 and nonhardy Jones Fife winter wheats were similar after photothermally induced hardening off. No chemical markers were observed that would be suitable for identifying changes related to frost tolerance.

Phosphorus Toxicity

In the growth room, leaves of P-deficient Selkirk wheat were damaged when P at 31 mg/litre was added to a P-deficient nutrient solution. Wheat plants grown in a solution containing P were not damaged. Maximum damage and P accumulation occurred in the apical region of the youngest leaves. The damage appeared to be due to the accumulation of abnormally high amounts of P in the leaves of P-deficient plants when P was made available to them.

In another experiment with Conquest barley, leaves of P-deficient plants were damaged after P was added to the hydroponic solution. As with wheat, the damaged leaves accumulated abnormally high amounts of P and the damage was most severe in the apical region of the youngest leaves. The fact that P accumulated in the leaf tips of P-deficient plants after P exposure but N did not, and that continuous exposure to high concentrations of P did not cause high tissue P, suggests a source-sink control mechanism, and not just transpirational uptake and accumulation.

TURKEY NUTRITION

Dietary Fat

Effect on storage stability. The abdominal depot fat of turkeys fed 11.4% dietary rapeseed oil became rancid when stored for 8 mo at -12°C , but not at -22°C . The depot fat of birds fed 11.4% palm oil was stable at both storage temperatures. A similar trend in thigh meat was not significant. Storage temperature did not affect the stability of breast meat. The instability of carcass fat of birds fed rapeseed oil compared with those

fed palm oil was associated with higher levels of linoleic and linolenic acids in the tissues.

Nutrient Density

Effect of pelleting. By using toasted full-fat soybean meal, it was possible to steam-pellet high nutrient density diets that contained 20% added fat. Four strains and two varieties of turkeys utilized the full-fat soybean meal as efficiently as the dehulled soybean meal plus animal tallow. Males fed the pelleted diets averaged 93% Grade A at 20 wk of age, whereas those fed the mash diets averaged 89% Grade A at 22 wk. The increase in growth rate was due to an increase in rate of physiological aging versus chronological aging.

Effect on carcass quality. Breast meat, wing meat, and skin percentage increased in strains A and C with each increase in nutrient density level. Breast meat and skin percentage increased with chronological age, and the drumstick, thigh, and wing percentage decreased with age. The lower nutrient density produced a higher drip loss than higher nutrient densities, and this was associated with the higher percentage of fat in the skin. Birds fed the higher nutrient density levels contained higher percentages of fat and protein in the breast and thigh tissue than the birds fed the lower nutrient density level. Percentage of fat in the skin was strongly associated with strain and chronological age. The fast-maturing strains had a higher percentage of fat in all tissues than the slower-maturing strains at comparable ages. The cold breast and backfat scores were highly correlated with the total skin fat and drip loss for both males and females.

Evaluation of feeding programs. Comparison of five commercial turkey broiler programs with control and increasing nutrient density programs designed at the Research Station, Swift Current, clearly demonstrated the need for improved monitoring of the quality of commercial feeds. Birds fed commercial rations required 86 to 110 days to reach market weight compared with 91 and 88 days respectively for birds on the control and increasing density programs. Feed consumption of the commercial rations varied from 8.6 to 11.9 kg compared with 9.2 and 8.2 kg consumption of feed for the control and increasing density programs. Feed conversion ranged from 1.98 to 2.60 compared

with 2.10 and 1.88 for the Swift Current programs. Carcass finish ranged from 93% to 66% Grade A and was poorest with the two commercial rations that gave the slowest growth. Net income over feed cost at June 1973 prices ranged from \$2.58 for the Swift Current control ration to \$2.17 for the least efficient commercial ration.

FORAGE

Breeding and Evaluation

Alfalfa. From 1962 to 1972, winter injury was recorded in 17 yield tests at the Research Station. Cultivars developed in the northern United States and in Canada were generally more winter-hardy than those developed in northern Europe. Cultivars classified as *Medicago media* were more winter-hardy than those classified as *M. sativa*. Very few United States cultivars but most Canadian cultivars were more winter-hardy than Vernal. Non-winter-hardy cultivars were seldom damaged during the first winter, but were often damaged during the second and third winters.

Clonal lines of creeping-rooted genotypes of *Medicago media* were evaluated for variability in developing creeping roots, winter-hardiness, and vigor. The genetic components of variance in the 2nd and 5th yr were 27% and 39% respectively for winterkilling and 57% and 39% for the creeping-rooted habit. A measure of plant spread was more accurate for assessing genotypes for creep than the percentage of plants with creeping roots. The genetic components of variance were 47% and 39% respectively. The creeping-root characteristic had not yet expressed itself in all clones of several lines by the 5th yr, indicating that there was a substantial microenvironmental influence on the expression of the characteristic. The percentage of creeping-rooted plants was negatively associated with winterkilling during the 2nd and 5th yr of growth.

Russian wild ryegrass. Progenies from a five-genotype diallel cross of Russian wild ryegrass were studied in the field to determine the pattern of genetic control for seed weight and seedling characteristics. Because of the triploid nature of the endosperm, 69% of the variation in seed weight was attributed to reciprocal or maternal effects, whereas variation for days to emerge was largely attributed to the effects of general combining

ability. Rate of leaf and tiller appearance showed strong effects of general and specific combining ability as well as maternal effects. Variation in seedling dry matter yield was largely controlled by specific combining ability.

Altai wild ryegrass. In 1968, selection for fast and slow germination was begun in Altai wild ryegrass. The plants were indexed for rate of germination, an index of 9 indicating slow germination and an index of 16 or more indicating rapid germination. In the original population, 1.6% of the plants had an index of less than 9 and 2.8% had an index of 16 or greater. After two cycles of recurrent selection, the fast-germinating population contained 4.2% of plants with an index of less than 9 and 45.2% of plants had an index of 16 or greater. The slow-germinating population contained 62.8% of plants with an index of less than 9 and no plants with an index of greater than 16.

Establishment of Grasses and Legumes

Effect of limited moisture. When grown in the greenhouse for 48 days in soils maintained at moisture levels of 60%, 40%, and 30% of field capacity, crested wheatgrass produced more shoot and root dry matter than Russian wild ryegrass at all moisture levels. At a soil moisture content of 30% of field capacity, the two grasses used equal amounts of soil moisture, but at 40% and 60% of field capacity, crested wheatgrass used more moisture than Russian wild ryegrass. The water use efficiency of crested wheatgrass was always greater than that of Russian wild ryegrass. Russian wild ryegrass is slower growing and consumes more water per gram of dry matter than crested wheatgrass, which places it at a disadvantage during establishment under semiarid conditions.

Effect of seed desiccation. Seeds of alfalfa, crested wheatgrass, and Altai and Russian wild ryegrasses were exposed to conditions favorable for germination, and then were either air-dried or oven-dried at 40°C for 2, 4, or 6 h. Seed of alfalfa was killed when germinated for 48 h and then desiccated for 2 h. Seed of the grasses germinated satisfactorily after being germinated for up to 72 h and dried for up to 6 h at room temperature or for 4 h at 40°C. The tolerance of the grasses for desiccation during emergence

makes them superior to alfalfa for establishment under semiarid conditions.

Survival of Grasses and Legumes

Tolerance for salinity. Tall wheatgrass, slender wheatgrass, Russian and Altai wild ryegrasses, brome grass, and reed canarygrass were examined for tolerance for salinity in soils ranging in conductivity from 4 to 40 mmhos/cm. Altai wild ryegrass, Russian wild ryegrass, and brome grass did not emerge as well as tall wheatgrass at high levels of salinity. Root yield of Altai wild ryegrass was greater than that of all other grasses at all levels of salinity. On the basis of forage yield, tall wheatgrass and Altai wild ryegrass tolerated salinity better than any of the other grasses. All grasses showed greatest sensitivity to salinity during germination and emergence.

Yield of Grasses and Legumes

Management of intermediate wheatgrass. When irrigated Chief intermediate wheatgrass was cut during the shot-blade stage and at 6-wk intervals thereafter during the 1st production yr, the stand was killed. Commencing cutting 2 wk earlier or 2 wk later during the 1st and 2nd production yr did not kill the stand or influence yield. Annual yields were influenced by variations in height of cutting and level of N availability and there were large interactions for most characteristics between the 1st and 2nd yr of production. Crude protein content of the forage from the first cut was decreased by delaying cutting. It was not influenced by height of cutting, but was increased by the application of N fertilizer.

Effect of light quality. In a growth room, alfalfa produced more herbage and more roots when the fluorescent portion of an incandescent-fluorescent light source consisted of 50% Gro-lux fluorescent tubes high in the blue-green-red portion of the light spectrum and 50% cool-white fluorescent tubes high in the blue-green-yellow-orange portion of the spectrum than when the light source consisted of only Gro-lux or cool-white tubes. Protein content and flowering were not affected by light source. *Medicago falcata*, *M. media*, and *M. sativa* types responded similarly to variations in light source. Cultivars tended to produce less herbage and fewer roots as the proportion of *M. falcata* germ plasma in them increased.

M. falcata flowered later than *M. sativa* in the growth room.

Suppressing seed culm formation on pastures. The development of seed culms by grasses in pastures reduces the quality of the forage. In clipping trials during 1970 to 1972 with Russian wild ryegrass, seed culm formation was prevented by stocking to have the forage grazed off by June 1. In similar trials with Altai wild ryegrass, seed culm formation was suppressed by removing the forage by mid-June. Removal of the forage early enough to suppress seed culm formation increased total forage production of Russian wild ryegrass, but did not affect the total amount of forage produced by Altai wild ryegrass.

Yield of bush pastures. A 12-yr study of forage yield in bush pastures was carried out in the Parkland areas of the Prairie Provinces extending from northwestern Alberta to southeastern Manitoba. The yield of native grasses increased with age of trees in the complex and, for a given tree age, increased from south to north. Average yields ranged from 200 kg/ha where trees were 30 to 35 yr old to 850 kg/ha where trees were 65 yr or older. Allowing for carryover and waste, which is high in bush pastures, carrying capacities ranged from about 4 ha per au (animal unit) for 5 mo to 11 ha/au for 5 mo, most pastures having a carrying capacity of about 8 ha/au for 5 mo. Too heavy stocking or too early grazing rapidly reduced the carrying capacity as well as the forage quality. Even the best bushland pastures produced only 10% to 20% of the yields obtained from tame pastures in the same area.

Flora of the Canadian Prairie Provinces

The first paper in the projected series, "Biological Flora of the Canadian Prairie Provinces," was published. This paper describes *Oxytropis besseyi* (Rydb.) Blank., a locoweed. The paper discusses the nomenclature, morphology, distribution, biotic factors, general biology, and history of this species.

ENVIRONMENT

Effect of Rainfall and Subsequent Drying on Availability of Nitrogen and Phosphorus

Chlorine-36 placed 15 or 30 cm below the surface of a fallowed loam in 15-cm-diam cylinders was leached to at least 50 cm during and immediately after a rainfall of more than 1.75 cm. As the soil dried after the rain, the ^{36}Cl moved upward. In the 0- to 2.5-cm soil segment of a 2nd-yr fallowed loam that was sheltered from rain, moisture was below the wilting percentage and $\text{NO}_3\text{-N}$ and bacterial numbers declined as the soil gradually dried out. In the 2.5- to 15-cm segment, moisture was in the available range, yet moisture and $\text{NO}_3\text{-N}$ changes were small. In unsheltered fallowed loam, $\text{NO}_3\text{-N}$ production in the 0- to 2.5-cm depth was primarily a function of daily soil moisture change. The increase in $\text{NO}_3\text{-N}$ during drying seemed to be more a result of upward movement than of nitrification. There was a negative linear relationship between daily change in $\text{NO}_3\text{-N}$ and bacteria in the 0- to 2.5-cm soil segment. Sodium-bicarbonate-soluble inorganic P generally exceeded NaHCO_3 -soluble organic P. In 2nd-yr fallow, P was unaffected by environmental conditions. In 1st-yr fallow, daily change in inorganic P in the 0- to 2.5-cm segment was directly related to rainfall, to daily change in percentage moisture, and to daily change in number of bacteria, and inversely related to daily change in $\text{NO}_3\text{-N}$.

Influence of Weather on Wheat Yield

Data compiled over a 50-yr period were used to develop a mathematical relationship between the yield of spring wheat and weather and to investigate the influence of changing weather conditions on wheat yield. In the earlier part of the period the climate was characterized by unsettled conditions involving hot, dry summers of a few to several years duration broken by spells of cool, wet summers. These conditions resulted in periods of drought accompanied by very low wheat yields intermingled with periods when yields were very high. During the past 15 summers, the weather has been characterized by normal to below-normal rainfall but with normal to below-normal temperatures. During these years the wheat yields were average to below average but much less

variable than during earlier years. The relationships indicate that in spite of low summer rainfall, yields during the last decade have been near normal because of cooler summer temperatures.

A mathematical model was developed which accounted for about 73% of the yield variability due to weather variations. The model treated summerfallow-season precipitation and growing-season rainfall as additive functions. These functions were modified progressively throughout the growing season on a monthly basis by correction factors, which were quadratic functions of monthly averages of the daily maximum and minimum temperatures and global radiation derived from measurements of bright sunshine. The model was set up to facilitate a month-by-month appraisal of the expected yield based on current and past weather. It is suggested that the mathematical equations could provide a practical and convenient model for making progressive estimates of wheat yield in a crop-condition surveillance program.

Microbial Studies of Sewage Effluent for Irrigation

A study was undertaken to determine if municipal sewage effluent from a second-stage lagoon at Swift Current can be used for sprinkler irrigation of alfalfa. Safety of handling the effluent through a sprinkler irrigation system, the quantity and quality of hay produced, and the long-term effects on the soil are being studied.

Consideration was first given to the pathogens and fecal bacteria in the effluent and to the effects of the effluent on the indigenous soil microflora. The effluent was consistently negative for intestinal parasites and pathogens, such as *Salmonella* spp., *Shigella* spp., and *Staphylococcus* spp. Coliforms and streptococci from feces were always present, but in the soil they were short-lived and there was no appreciable downward movement. Further, large proportions of the effluent microflora, particularly the fecal bacteria, were killed by the sudden pressure changes that normally occur in the pumping system. Viable populations of indigenous soil fungi, bacteria, and actinomycetes increased more in response to effluent irrigation and persisted longer than when surface water was used for irrigation. The nutrients contained in the effluent appeared to be primarily responsible

for the strong stimulation of soil microbial activity.

Initiation of Soil Erosion

In the initiation of the movement of soil particles by wind, impulse forces due to turbulent air flow cause the soil aggregates to leave the surface in a vertical direction rather than by rolling to gain momentum for upward movement. The total pressure of the air, which is the barometric pressure or stagnation pressure, in the region where the aggregate is positioned results in impulsive forces, which initiate movement. Immediately above the region of stagnation, there is an instantaneous decrease in static pressure at the instant of the maximum momentary velocity in turbulent flow. The instantaneous pressure difference results in the impulse on the aggregate. The effect of this impulse provides the momentum that the aggregate has when it leaves the surface. The lift forces, which approach the weight of the aggregate, can be simply expressed by relating the dynamical and potential energy involved. The effect of the impulse can be described as $\int \delta F dt$, but the force or time is not measurable.

RESEARCH EQUIPMENT

Drying System for Forage Samples

A system was developed for drying up to 768 samples of chopped, green forage in 24 h. The drying cabinet is $9.6 \times 1.8 \times 2.0$ m high. It is made up of six compartments, three on each side, divided in the center by a plywood partition. Each compartment has four shelves, each designed to hold 32 plastic containers in such a way that the air must pass through the forage in the container during drying. Air at a temperature of 66°C is brought in at the top of each compartment, passed down through the forage samples, and evacuated through a duct underneath the compartments.

Each 7.5-litre, heat-resistant, plastic container, which has a perforated bottom, is loaded with approximately 300 g of chopped, green forage in the field. At the end of the harvesting day, the containers are placed in the dryer. Usually only three compartments are required for drying the samples from each day's harvest and with a moisture content of 70% these can be dried in 14 h. Although the samples are ready for

weighing the next morning, they do not have to be weighed until the afternoon of the following day, when the space is required for another set of samples.

Volumetric Fertilizer Applicator

A precision volumetric fertilizer applicator was developed for the six-row Swift Current seeder. The applicator has three separate compartments and metering devices for N, P, and K fertilizers. Each metering device consists of a sintered-metal seed roll mounted in a machined stainless steel housing and operating in the overshot mode. The rate of application of each nutrient is obtained by selecting the proper rate of revolution of the metering device in relation to ground speed. This is done by precisely positioning the lever on each of the three infinitely adjustable drives. By doing this the operator can actually dial the required combination of nutrients for each plot in amounts of up to 600 kg/ha. The accuracy of distribution is $\pm 2\%$ with fertilizers of constant bulk density.

Modifications to the Hege Combine

Three modifications were made to the Hege combine to make it possible for three men to harvest up to 1,700 cereal yield test plots in a 10-h day. A compressed-air system was added for cleaning the cylinder between plots. This consists of a compressor that feeds air to seven fixed nozzles mounted so that the air blast hits the concave at the cylinder inlet. Cleaning requires only the pushing of a control button by the operator. The second modification was the addition of a dispenser for the paper bags used to collect samples. Six cartridges, each holding two hundred and fifty 2.3-kg paper bags, are preloaded. The operator can quickly take one bag at a time from the dispenser. The third modification was replacement of the existing fan with a cross-flow fan that had a more uniform velocity profile. The air plenum was modified to extend the air outlet across the complete width of the fan. The air blast is varied by regulating the speed of the fan by means of a spring-loaded, variable-speed pulley. Also, the fixed grain sieve was replaced with an adjustable sieve.

PUBLICATIONS

Research

- Biederbeck, V. O., and Campbell, C. A. 1973. Soil microbial activity as influenced by temperature trends and fluctuations. *Can. J. Soil Sci.* 53:363-366.
- Bisal, F. 1973. Initiation of movement of soil aggregates. *Can. J. Soil Sci.* 53:481-482.
- Campbell, C. A., Biederbeck, V. O., and Warder, F. G. 1973. Influence of simulated fall and spring conditions on the soil system: III. Effect of method of simulating spring temperatures on ammonification, nitrification, and microbial populations. *Soil Sci. Soc. Am. Proc.* 37:382-386.
- Campbell, C. A., Biederbeck, V. O., Warder, F. G., and Robertson, G. W. 1973. Effect of rainfall and subsequent drying on N and P changes in a dryland fallow loam. *Soil Sci. Soc. Am. Proc.* 37:909-915.
- Coxworth, E. C. M., and Salmon, R. E. 1972. Kochia seed as a component in the diet of turkey poults; effect of different methods of saponin removal or inactivation. *Can. J. Anim. Sci.* 52:721-729.
- Green, D. G., and Warder, F. G. 1973. Accumulation of damaging concentrations of phosphorus by leaves of Selkirk wheat. *Plant & Soil* 38:567-572.
- Green, D. G., Ferguson, W. S., and Warder, F. G. 1973. Accumulation of toxic levels of phosphorus in the leaves of phosphorus-deficient barley. *Can. J. Plant Sci.* 53:241-246.
- Heinrichs, D. H. 1973. Influence of light source on the growth of alfalfa cultivars. *Can. J. Plant Sci.* 53:291-294.
- Heinrichs, D. H. 1973. Time factor in expression of the creeping-rooted character in alfalfa. *Can. J. Plant Sci.* 53:511-514.
- Heinrichs, D. H. 1973. Winterhardiness of alfalfa cultivars in southern Saskatchewan. *Can. J. Plant Sci.* 53:773-777.
- Hinman, W. C., and Bisal, F. 1973. Percolation rate as affected by the interaction of freezing and drying processes of soils. *Soil Sci.* 115:102-106.
- Hurd, E. A., Townley-Smith, T. F., Mallough, D., and Patterson, L. A. 1973. Wakooma durum wheat. *Can. J. Plant Sci.* 53:261-262.

- Kilcher, M. R., and Troelsen, J. E. 1973. Contribution and nutritive value of the major plant components of oats through progressive stages of development. *Can. J. Plant Sci.* 53:251-256.
- Kilcher, M. R., and Troelsen, J. E. 1973. Contribution of stems and leaves to the composition and nutrient content of irrigated brome grass at different stages of development. *Can. J. Plant Sci.* 53:767-771.
- Lawrence, T. 1973. Productivity of intermediate wheatgrass as influenced by date of initial cutting, height of cutting, and N fertilizer. *Can. J. Plant Sci.* 53:295-301.
- Lawrence, T. 1973. Control of Russian wild ryegrass seed culm formation by spring cutting. *Can. J. Plant Sci.* 53:547-548.
- Lawrence, T. 1973. Control of seed culm formation in Altai wild ryegrass by spring cutting. *Can. J. Plant Sci.* 53:549-550.
- Lawrence, T. 1973. Seed yield of Altai wild ryegrass as influenced by aftermath removal. *Can. J. Plant Sci.* 53:545-546.
- Looman, J. 1973. Biological flora of the Canadian Prairie Provinces. I. *Oxytropis besseyi* (Rydb.) Blank. *Can. J. Plant Sci.* 53:677-687.
- Looman, J., and Heinrichs, D. H. 1973. Stability of crested wheatgrass pastures under long-term pasture use. *Can. J. Plant Sci.* 53:501-506.
- McElgunn, J. D. 1973. Germination response of forage legumes to constant and alternating temperatures. *Can. J. Plant Sci.* 53:797-800.
- McElgunn, J. D., and Lawrence, T. 1973. Salinity tolerance of Altai wild ryegrass and other forage grasses. *Can. J. Plant Sci.* 53:303-307.
- Read, D. W. L., Spratt, E. D., Bailey, L. D., Warder, F. G., and Ferguson, W. S. 1973. Residual value of phosphatic fertilizer on Chernozemic soils. *Can. J. Soil Sci.* 53:389-398.
- Salmon, R. E., and O'Neil, J. B. 1973. The effect of the level and source and a change of source of dietary fat on the fatty acid composition of the depot fat and the thigh and breast meat of turkeys as related to age. *Poult. Sci.* 52:302-314.
- Salmon, R. E., and O'Neil, J. B. 1973. The effect of dietary fat and storage temperature on the storage stability of turkey meat. *Poult. Sci.* 52:314-317.
- Thompson, J. L., Heinrichs, D. H., and Guitard, A. A. 1973. Cabinet-type drying oven for forage samples. *Can. J. Plant Sci.* 53:823-826.
- Townley-Smith, T. F., and Hurd, E. A. 1973. Use of moving means in wheat yield trials. *Can. J. Plant Sci.* 53:447-450.

Miscellaneous

- Anderson, C. H. 1973. Herbicides and summerfallow. *Farm Light & Power* 15(3):24.
- Biederbeck, V. O., and Campbell, C. A. 1973. Spring can be hard on microorganisms. *Crops & Soils* 25(5):28-29.
- Campbell, C. A., Biederbeck, V. O., and Warder, F. G. 1973. Effect of rainfall on N and P changes in fallow loam. Pages 88-97 in *Proc. 1973 Soil Fertility Workshop, Saskatoon, Sask.*
- Campbell, C. A., Biederbeck, V. O., and Warder, F. G. 1973. Effect of growing season soil temperature on nitrification. Pages 98-103 in *Proc. 1973 Soil Fertility Workshop, Saskatoon, Sask.*
- Dunkelgod, K. E. 1973. Lower nutrient density diets can spell waste of nutrients for the growing turkey. *Can. Poultryman* 60(12):20-22.
- Kilcher, M. R. 1973. Value of oats as whole-plant feed. *Canadex* 113.50.
- Looman, J. 1973. Some new and interesting plant records for the Prairie Provinces. *The Blue Jay* 31:176-179.
- McBean, D. S. 1973. Cooperation in developing wheat varieties. *Can. Agric.* 18(1):10-11.
- Nicholaichuk, W. 1973. Sodium carbonate method of pond seepage control. *Canadex* 576.
- Paul, E. A., Biederbeck, V. O., Lowe, W. E., and Willard, J. R. 1973. Soil microorganisms: I. Population dynamics of bacteria and actinomycetes. Technical Report No. 37. Canadian Committee for the International Biological Programme, Matador Project. 79 pp.
- Salmon, R. E. 1973. The protein problem. *Can. Poult. Rev.* 97(10):54-55.
- Salmon, R. E. 1973. The feed problem, today and tomorrow. *Can. Poultryman* 60(11):54-55.
- Salmon, R. E. 1973. Least cost rations, or least cost performance? *Can. Poultryman* 60(12):18-19.
- Sommers, L. E., and Biederbeck, V. O. 1973. Tillage management principles: Soil microorganisms. Pages 87-108 in *Conservation tillage. Proc. Nat. Conf. sponsored by Soil Cons. Soc. Am., Ankeny, Iowa.*

Stewart, D. W. 1973. Simulation modelling of plant processes and microclimate in relation to net assimilation. Grassland species. Pages 215-230 *in* Measurement and modelling of photosynthesis in relation to productivity, Int. Biol. Programme, Proc. Guelph Workshop.

Research Station Beaverlodge, Alberta

PROFESSIONAL STAFF

L. P. S. SPANGELO, B.S.A., M.Sc., Ph.D.
M. D. HAMILTON

Director
Administrative Officer

Environment and Special Crops Section

R. E. HARRIS, B.S.A., M.S.A., Ph.D.

Head of Section; Environment and
special crop breeding

A. L. DARWENT, B.S.A., M.Sc., Ph.D.

Weed research

J. G. N. DAVIDSON, B.S.F., M.Sc., Ph.D.

Plant pathology

J. S. MCKENZIE, B.Sc., M.Sc., Ph.D.

Plant survival

Cereal and Oilseed Crops Section

D. G. FARIS, B.S.A., M.S.A., Ph.D.

Head of Section; Cereal breeding

R. M. DEPAUW, B.A., M.Sc., Ph.D.

Wheat and rapeseed

Forage Crops Section

C. R. ELLIOTT, B.Sc., M.Sc., Ph.D.

Acting Head of Section; Grass
seed management

S. G. BONIN, B.S.A., Ph.D.

Grass breeding

D. L. NELSON, B.S.A., M.Sc.

Apiculture

P. PANKIW, B.S.A., M.Sc., Ph.D.

Legume seed management

W. L. PRINGLE, B.S.A., M.S.F.

Production and utilization

Soils Section

W. A. RICE, B.S.A., M.Sc., Ph.D.

Acting Head of Section;
Microbiology

A. M. F. HENNIG, B.Sc.

Crop management

P. B. HOYT,¹ B.S.A., M.S., Ph.D.

Organic matter relationships

R. H. LEITCH, B.Sc., M.Sc.

Soil fertility

Experimental Farm, Prince George, B.C.

W. K. DAWLEY, B.S.A.

J. N. TINGLE, B.S.A., M.Sc.

Superintendent; Forage utilization
Forage management

Experimental Farm, Fort Vermilion, Alta.

B. SIEMENS, B.S.A., M.Sc.

Superintendent; Forage crops
management

VISITING SCIENTIST

W. B. CHARLES, B.S.A., M.S.A., D.I.C.T.A.

Tomato physiology

University of West Indies, St. Augustine, Trinidad.

Canadian International Development Agency.

¹On special assignment to Tanzania, September 1973 to September 1975.

INTRODUCTION

The Northern Research Group, which comprises the Research Station at Beaverlodge and the associated experimental farms at Fort Vermilion, Alta., and Prince George, B.C., continued research on agricultural problems of northwestern Canada. This report summarizes research carried out in 1973. This year more than 35 cm of snow fell during August at Beaverlodge. Because of the extremely variable climate in this area, a better understanding of the response of crops to these changes is needed. Climatic variation from year to year, and total environmental variation between close production areas are factors affecting crop-environment relationships, which are under study by the Northern Research Group. Crop failures still occur too frequently in parts of northwestern Canada. Superior cereal, oilseed, and forage crop cultivars and improved cultural procedures are required.

A comprehensive assessment of plant diseases affecting crops in the Peace River region was carried out. An intensive study on winter survival of perennial forage crops was initiated. Another scientist joined the staff of the Cereal and Oilseed Crops Section to work on a utility wheat program. A publication on farming acid soils was written after 13 yr of research on the toxicity of Al and Mn in acid soils.

Research on forage crop production and management continued as a main thrust at Fort Vermilion and Prince George. Research on forage utilization with beef animals was carried out at Prince George.

The Northern Research Group is pleased that Dr. P. B. Hoyt is on a special 2-yr agronomic research assignment in Tanzania for the Canadian International Development Agency.

This report and reprints of the publications are available on request. Correspondence to individual research scientists should be addressed to: Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta. T0H 0C0; Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta. T0H 1N0; or Experimental Farm, Research Branch, Agriculture Canada, Prince George, B.C. V2N 2H8.

L. P. S. Spangelo
Director

APICULTURE

Breeding

New Zealand vs. California queens for honey and package production. From 1968 to 1970, queens imported from New Zealand were compared with queens imported from California for honey production in the Beaverlodge area and for wintering and package bee production in the lower Fraser Valley, B.C. Honey production of both queen types was similar. The New Zealand bees were more gentle but slightly more susceptible to European foulbrood. In wintering studies, both groups consumed similar amounts of feed. The New Zealand queens produced fewer brood in late winter and early spring, resulting in a significantly lower package bee production than was produced by the California queens. However, New Zealand bees can provide a satisfactory alternative to California queens for honey production.

Hybrid queens (New Zealand \times California) vs. their parental stocks for colony development and honey production. Hybrid queens were compared with their parental stocks, California queens (1971-73) and New Zealand queens (1971-72), to evaluate colony development and honey production at Beaverlodge. Our results demonstrated that no advantage was gained by crossing New Zealand queens with California drone stock for improving either colony development or honey production.

CEREAL CROPS

Physiology

Performance of barley and wheat sown in the fall and spring. Barley (Jubilee and Olli) and wheat (Thatcher, Park, and Pitic 62) were seeded at Beaverlodge, Fort Vermilion, and Edmonton in the fall and spring of 1969-70 and 1970-71. Spring seedings gave

better yields and were no later maturing than fall seedings. Early spring seedings gave similar yields to later spring seedings but were consistently earlier maturing.

ENVIRONMENT

Instrument Evaluation

Four types of rain gauges and three methods of measuring snowfall. The standard precipitation gauge used by the United States National Weather Service (formerly called U.S. Weather Bureau) was the most reliable instrument for measuring rain at all intensities, whereas the Nipher gauge used by the Atmospheric Environment Service of Canada (previously known as the Meteorological Service of Canada) was superior to other snow gauges for measuring snowfall.

The standard rain gauge used by the Atmospheric Environment Service of Canada sometimes seriously undercaught during intense rain. The cause seemed to be the intensity of the rain, not the wind velocity.

Under blizzard conditions, both the snowboard and the Alter shielded gauge used by the U.S. National Weather Service were unsuitable for measuring snowfall.

Plant Survival

The initiation of cold acclimation. In red-osier dogwood, *Cornus stolonifera* Michx., the initiation of cold acclimation is phytochrome mediated. Under controlled conditions, short days or end-of-day far-red light exposure after long days promote growth cessation, cold acclimation, and subsequent hardening in response to low temperature. Nuclear magnetic resonance absorption spectra of the water in the internode stem sections showed that the phase of cold acclimation induced by short days involves a change in tissue hydration due, in part, to a substantial reduction in bulk-phase water at senescence and the accompanying loss of water from the pith. This appeared to be induced by a decrease in the relative stomatal resistance of leaves and a 3.5-fold increase in the resistance to water flow through roots at the initiation of cold acclimation. Additional hardening to -40°C resulted in a 28-fold increase in resistance to water flow through roots. The initial change in resistance to water flow through roots appeared to be due to changes in water permeability of root cell membranes but as hardening progressed,

root surfaces became suberized, giving rise to an additional barrier to water uptake in very hardy plants. This research was conducted in cooperation with Dr. C. J. Weiser at the Laboratory of Plant Hardiness, University of Minnesota.

Crop Diseases

A comprehensive assessment of diseases affecting crops grown in the Peace River district was carried out for the first time. Stem eyespot of creeping red fescue is the most serious problem. Winterkill of forage legumes, especially alfalfa, is also a major concern. A root rot, called brown girdling root rot of rape, is the most prevalent and most serious disease of rape throughout the district.

Weed Control

Distribution of toadflax. In a survey to determine the distribution of toadflax, *Linnaria vulgaris* Mill., in the Peace River region of northwestern Alberta, 4,192 ha were found to be moderately or heavily infested. Approximately 47% of the infested land was used for perennial forage crops, 45% for annual crops, and the rest was found on abandoned lands or in farmyards and woodland. Comparison with estimates made in 1956 shows that the weed is not increasing and may be decreasing in many of the survey areas. Two biological control agents, the beetles *Brachypterolus pulicarius* (L.) and *Gymnaetron antirrhini* (Payk.), along with improved tillage practices appear to be the major factors restricting the spread of toadflax.

Physiology

Effect of day length and temperature on the elongation of red raspberry cultivars. Sudden drops in temperature during July and early August 1968 resulted in a sharp decline in the daily rate of elongation. In analyses that were completed this year, it was found that the combination of shorter day length and lower temperatures prevented rapid elongation after August 15, and eventually resulted in the termination of elongation during early September. On June 6, 1968, there were no significant differences in cane height among the cultivars Viking, Redman, Latham, and Trent. At the termination of elongation on September 9, canes of the cultivar Trent were significantly shorter than

those of Viking, but equal to Redman and Latham.

Influence of latitude and environment on potato evaluation. In tests at six separated locations in Northwestern Canada, the number of tubers decreased with increasing latitude but not the marketable number, or the total and marketable weight of tubers. Similarly, tuber type, specific gravity, boiled quality, or general evaluation were not affected by latitude.

The performance and evaluation ratings of cultivars grown at Prince George, Beaverlodge, Anzac, Mile 1019, and Fort Simpson were similar but they differed from the ratings at Fort Vermilion.

It was concluded that evaluation of potato cultivars was needed at two locations in Northwestern Canada; one at Fort Vermilion and the other at any of the five other locations, and that potato research at the five other locations should be directed to improving cultural practices.

FORAGE CROPS

Herbage Production

Timothy and reed canarygrass for pasture. Beef production on timothy pastures during 1971–73, inclusive, averaged 732 kg/ha compared with 624 kg/ha on reed canarygrass pastures. The average daily gains of steers on timothy pastures was 929 g compared with 838 g for those on reed canarygrass. The carrying capacity of pastures as measured by steer days/ha averaged 370 on timothy compared with 350 on reed canarygrass.

This research required a high degree of pasture management. Nitrogen was applied in split applications of 78 and 33 kg/ha in early spring and midseason. Seed heads were removed by clipping at time of initial heading. One trimming was sufficient for reed canarygrass but timothy required several trimmings.

Row spacing of hay crops. Average yields over 3 yr of Rambler alfalfa were 5,300 kg/ha from a 15-cm row spacing and 6,000 kg/ha from a 50-cm spacing; row spacings wider than 50 cm produced less than either of these. Manchar brome grass in the close row (15 cm) produced 5,600 kg/ha and in the wider spacing (50 cm) 6,300 kg/ha. Frontier reed canarygrass produced 4,600 kg/ha in

the close row and 6,400 kg/ha in the 50-cm spacing. Wider spacings up to 125 cm produced significantly less than the 50-cm spacing, which, for some perennial crops, may be optimum. The greatest differences in yield due to row spacing occurred in the drier years and in the second cutting.

Cu and Zn in rations for beef heifers. In the Peace River region, beef heifers fed a ration containing 3–4 ppm Cu and 25–32 ppm Zn did not respond to rations supplemented to 11–12 ppm Cu and 65 ppm Zn. A slight increase in Cu levels occurred in the liver, but feed consumption, average daily gains, and dressing percentages were similar. It was shown that on a full-feed regime for 134–151 days, young animals with Cu levels of 100 ppm dry weight in the liver can maintain a normal metabolic balance even though their ration is analytically low in Cu and Zn, particularly where the Cu-to-Mo ratio is favorable.

Forage quality of cultivated grass species and cultivars within species. Fifteen species of grass harvested at the early heading stage at Prince George varied in dry matter yield and levels of dry matter digestibility, crude protein, Ca, K, Mg, Zn, Mn, and Cu. The levels of Ca and Mg required for optimum livestock production (established by the National Academy of Sciences) varied with the species of grass. Each parameter except Mg and Cu concentrations exhibited differences between cultivars within certain of eight species. Only timothy had cultivar differences in dry matter digestibility. Crude protein levels varied between cultivars of meadow fescue and Kentucky bluegrass. Differences between species were greater than between cultivars within species.

Forage species evaluation. Climax timothy produced more dry matter over a 3-yr period than Lofar, L84, Barenza, Vanadis, Omnia, and Kaempe II at Prince George. Baylor and Blair brome grass outyielded Carlton. Steinacher creeping red fescue was equal to Boreal in dry matter yield. Tepa red clover outproduced Reichersberger over a 2-yr period but all red clover cultivars were winterkilled during 1972–73. Greenleaf and Mandan pubescent wheatgrass, Siberian wild ryegrass, and Tualtin tall oatgrass were also winterkilled. Sawki Russian wild ryegrass and Altai wild ryegrass failed to establish on the heavy clay soil.

Seed Production

Isolation of red clover. A recessive white flower marker was used to determine contamination of seed of the cultivar Lasalle, at various isolation distances from a contaminant source. The percentage of contamination at isolation distances of 0, 46, 91, 183, and 274 m was 4.7, 4.5, 3.4, 2.5, and 2.6. A 2-m border around the plots reduced the contamination in the 0-, 46-, and 91-m plots to less than 3%, an acceptable standard for pedigreed seed. The use of borders is an alternative to isolation distances for larger areas where border removal is feasible.

Orientation of nesting material for alfalfa leafcutter bees. Nesting materials facing south, east, and west were placed in a polyethylene domicile facing south. The bees preferred the nesting material with southern exposure and used the eastern and western exposure reluctantly when the other tunnels had been filled.

HORTICULTURE

Breeding

'Trailman'—a new apple-crab cultivar. In the Peace River region, Trailman is a hardy, vigorous apple-crab, which comes into production at an early age and consistently produces a heavy crop. The cultivar was selected from Trail \times Osman seedlings obtained from the Prairie Cooperative Fruit Breeding Project. The original tree has consistently produced heavy crops since 1953, and grafted and budded trees have been producing since 1969 at Beaverlodge and 1971 at Saskatoon.

The tree is vigorous, upright spreading, and hardier than Rescue. Fruits are of uniform size, 4.5 cm in diam by 4.3 cm long. The skin is yellow, overlaid by a reddish brown on the side exposed to the sun. The flesh is golden yellow, crisp, and juicy. The flavor is similar to Trail, but milder and more pleasant. The storage quality of Trailman is superior to Rescue.

SOILS

Soil Microbiology

Effect of soil acidity on nitrogen fixation by alfalfa and red clover. Populations of *Rhizobium meliloti* in the soil, formation of nodules, and relative yields (yield without fertilizer N/yield with fertilizer N) of alfalfa

decreased sharply as the soils became more acid. When the soil pH was 6.0 or higher, there were negligible effects of pH on the above factors. Soil pH in the range studied (4.5–7.2) had no effect on nodule formation or relative yields of red clover. However, populations of *R. trifolii* were reduced when the pH of the soil was below 4.9.

Effect of inoculum level on nodulation and growth of alfalfa in acid soil. When enough lime (2 mg CaCO_3/g soil) was added to an acid Orthic Gray Luvisol soil to decrease soluble Al to subtoxic levels, the forage yield of alfalfa was increased 85, 72, and 130% by applying inoculum at 3×10^2 , 3×10^4 , and 3×10^7 rhizobia/seed. The inoculum level had no significant effect on the total fresh weight of nodules, but when inoculum levels were increased, the amount of effective nodules increased and the amount of ineffective nodules decreased. These results demonstrate the need for adequate quantities of good-quality inoculum for growing alfalfa on soil with low pH.

Soil Fertility

Effect of time of grass sod breaking on crop growth. In 1971, soil available $\text{NO}_3\text{-N}$ measured to a depth of 46 cm in sod that had been broken in 1970 was 33, 16, and 10 kg/ha for July, August, and October sod breaking. The same breaking strips fallowed in 1970 had $\text{NO}_3\text{-N}$ contents of 64, 39, and 35 kg/ha in the spring of 1971. Similar results were obtained in 1972, when fallowed fescue sod breaking was again sampled in the spring. The 3-yr mean yields of seed and the percentage protein content of Galt barley (seeded the year after breaking and after fallowed breaking) were highest for July breaking and lowest for October breaking over all fertilizer treatments. For all breaking dates in the 3 yr, the yield and percentage of protein were increased by increasing the rate of N from 0 to 135 kg/ha broadcast at time of seeding. This averaged 9.8 q/ha increase in barley seed and 2.7% increase in seed protein.

N broadcast at time of seeding was the most effective application time for increasing barley yield; less response was shown at the flag-leaf stage, and no response at time of flowering. However, for increasing protein, N applied at the flag-leaf stage was the most effective, followed by application at flowering, and then at seeding.

PUBLICATIONS

Research

- Boyd, M. M., Garrison, C. S., Elliott, C. R., and Valle, O. 1971. The stability of cultivars of grasses and clovers when grown for seed in different environments. *J. Natl. Inst. Agric. Bot.* 12(2):267-278.
- Briggs, K. G., and Faris, D. G. 1973. Performance of spring wheat and barley cultivars sown in the fall and spring in northern Alberta. *Can. J. Plant Sci.* 53:743-747.
- DePauw, R. M., and Shebeski, L. H. 1972. An evaluation of an early generation yield testing procedure in *Triticum aestivum*. *Can. J. Plant Sci.* 53:465-470.
- Elliott, C. R., Hoyt, P. B., Nyborg, M., and Siemens, B. 1973. Sensitivity of several species of grasses and legumes to soil acidity. *Can. J. Plant Sci.* 53:113-117.
- Harris, R. E. 1973. Relative hardiness of strawberry cultivars at three times of the winter. *Can. J. Plant Sci.* 53:147-152.
- Hennig, A. M. F., and Schaffter, W. 1973. The Alberta Soil Sampler modified for sample collection. *Can. J. Soil Sci.* 53:347.
- Nelson, D. L., and Jay, S. C. 1972. Population growth and honey yield studies of package bee colonies in Manitoba. II. Colonies initiated with four package sizes on one date. *Manit. Entomol.* 6:17-22.
- Nelson, D. L., and Jay, S. C. 1972. Estimating numbers of adult honey bees on Langstrath frames. *Manit. Entomol.* 6:5-8.
- Pringle, W. L., Dawley, W. K., and Miltimore, J. E. 1973. Sufficiency of Cu and Zn in barley, forage and corn silage rations as measured by response to supplements by beef cattle. *Can. J. Anim. Sci.* 53:497-502.
- Pringle, W. L., Elliott, C. R., and Dobb, J. L. 1973. Aspen poplar regrowth on pastures of the Peace River region. *J. Range Manage.* 26(4):260-262.

van Adrichem, M. C. J. 1973. Elongation of red raspberries. *Can. J. Plant Sci.* 53:349-350.

Miscellaneous

- Elliott, C. R. 1973. Grass seed yield data. North. Res. Group Publ. 73-4. 16 pp.
- Elliott, C. R., and Baenziger, H. 1973. Creeping red fescue. *Can. Dep. Agric. Publ.* 1122 (revised). (French and English) 19 pp.
- Elliott, C. R., and Hiltz, M. E. 1973. Forage introductions. North. Res. Group Publ. 73-16. 26 pp.
- Elliott, C. R., and Hoyt, P. B. 1973. Forages for Peace River acid soils. *Can. Agric.* 18(1):15.
- Goplen, B. P., Cooke, D. A., and Pankiw, P. 1973. Isolation distances required for sweetclover seed production. *Can. Agric.* 18(3):13-14.
- Harris, R. E. 1973. Le jardinage sur pergélisol. *Can. Dep. Agric. Publ.* 1408. 18 pp.
- Harris, R. E., Carder, A. C., Pringle, W. L., Hoyt, P. B., Faris, D. G., and Pankiw, P. 1972. Farming potential of the Canadian Northwest. *Can. Dep. Agric. Publ.* 1466. 26 pp.
- Nelson, D. L. 1973. The bear facts. *Can. Beekeeping* 4(1):1.
- Nelson, D. L., and Pankiw, P. 1973. Nectar flow records at Beaverlodge 1954-1972. *Can. Beekeeping* 4(4):29.
- Pankiw, P. 1973. Management of the alfalfa leafcutter bee (*Megachile rotundata*) in North-western Canada. North. Res. Group Publ. 73-2. 4 pp.
- Pankiw, P., Goplen, B. P., and Cooke, D. A. 1973. Isolation distances for sweetclover seed production. *Canadex* 123.15.
- Pringle, W. L. 1973. Plant germplasm from the North. *Can. Agric.* 18(4):32-33.
- Rice, W. A. 1973. Microbiological relationships of solonchic soils. Pages 62-65 in *Solonchic soils technology and management*. Univ. of Alta., and Agric. Can. Bull. B-73-1. 92 pp.

Research Station Lacombe, Alberta

PROFESSIONAL STAFF

J. G. STOTHART, D.S.O., B.S.A., M.Sc., F.A.I.C.	Director
W. J. MURRAY	Administrative Officer

Animal Science Section

H. T. FREDEEN, B.S.A., M.Sc., Ph.D., F.A.I.C.	Head of Section: Animal breeding
J. A. BRADLEY, ¹ M.R.C.V.S.	Veterinarian science
H. DOORNENBAL, B.S.A., M.S.A., Ph.D.	Physiology
A. H. MARTIN, B.S.A., M.S.A.	Meats research
J. A. NEWMAN, B.Sc., Dip. An. Gen., Ph.D.	Population genetics
E. H. REIMER (Mrs.)	Systems and programming

Plant Breeding Section

M. L. KAUFMANN, C.D., B.S.A., M.Sc., Ph.D.	Head of Section: Barley breeding
H. T. ALLEN, B.Sc., M.Sc.	Cereal crops
W. B. BERKENKAMP, B.S., M.S., Ph.D.	Plant pathology
L. P. FOLKINS, B.S.A., M.Sc.	Forage crops
L. J. PIENING, B.Sc., M.Sc., Ph.D.	Plant pathology

Crop Management and Soils Section

H. A. FRIESEN, B.S.A., M.Sc.	Head of Section: Weed research
D. A. DEW, B.E.	Crop management
D. K. McBEATH, B.S.A., M.Sc., Ph.D.	Plant nutrition
D. R. WALKER, B.Sc., M.Sc.	Soil chemistry

Solonetzic Soil Substation, Vegreville

R. R. CAIRNS, B.S.A., M.Sc., Ph.D.	Officer-in-charge: Soil physics and chemistry
------------------------------------	---

Departures

L. A. HEAPY, B.Sc., Ph.D.
Resigned August 17, 1973
G. M. WEISS, B.S.A., M.Sc.
Resigned May 31, 1973

Plant nutrition

Biostatistics

VISITING SCIENTIST

A. NISHIDA, B.Sc., Ph.D.
National Research Council postdoctorate fellow

Population genetics

¹Seconded from Health of Animals Branch, Agriculture Canada.

INTRODUCTION

Climatic conditions were generally excellent for growth throughout most of central and north central Alberta in 1973. It was a particularly good year to evaluate resistance to lodging in cereals, and several promising lines are being developed in our barley and oat breeding programs. With the increase of interest in feed grains for both the domestic and the export market, it is apparent that research into productivity, or factors affecting productivity such as soil fertility, weed control, and disease resistance, will be of increasing importance.

Our meats research program has demonstrated that entire bovine and porcine males grow faster and produce leaner carcasses than do castrates or females. From a consumer's point of view the meat from bulls under suitable management was entirely satisfactory, and only about 15 to 20% of young boars produced tainted pork. This acceptability, combined with the more economic production of males, may well offset the traditional objections to their use.

This report is a summary of the main findings of the research program at Lacombe in 1973. Further details are available. Please address correspondence to: Research Station, Research Branch, Agriculture Canada, Lacombe, Alta. T0C 1S0.

J. G. Stothart
Director

ANIMAL SCIENCE

Beef Cattle

Response to selection for yearling weight. Ten years of selection for yearling weight in two replicate herds of beef Shorthorns resulted in genetic increases of 4.8 ± 3.1 and 4.1 ± 3.0 kg/yr in males and 3.3 ± 2.7 and 2.3 ± 1.5 kg/yr in females. These increases were measured as deviations from an unselected control line and comprised about 45% of the absolute increase in yearling weight that occurred during the selection program. Based on a comparison of the selection intensity practiced with the performance change observed, the realized heritabilities for males were 0.49 ± 0.12 and 0.51 ± 0.16 for the two replicates. These estimates were confirmed by results obtained from a study of line crosses.

Crossbreeding. Hereford-cross calves sired by bulls of the Maine-Anjou, Simmental, and South Devon breeds were compared for several beef production traits. For birth weight, weaning weight, and average daily gain in feedlot, the progeny groups ranked Maine-Anjou > Simmental > South Devon ($P < 0.001$). For average fat depth over the rib, adjusted for differences in carcass weight, the groups ranked South Devon > Maine-Anjou = Simmental ($P < 0.05$). For weight of trimmed, deboned, defatted lean per day of age the ranking was Maine-Anjou

> Simmental > South Devon ($P < 0.01$). Breed-of-sire differences for area of rib eye per unit of carcass weight and percentage yield of lean meat were not statistically significant.

Control of calf scours. Studies have continued on the incidence, treatment, and control of scours in newborn calves. Early treatment, mainly by antibiotics, combined with management techniques to reduce stress in the newborn calf proved highly successful; incidence decreased from 66% in 1970 to 8% in 1973, and losses were reduced from 15% to zero. The feasibility of controlled field trials is under study.

Swine

Joint damage among performance-tested boars. Data from dissection of the leg joints of 160 boars slaughtered immediately after performance test revealed extensive cartilage damage and bleeding into the synovial fluid. Few of the joints examined were fully normal, and more than 40% of the boars showed moderate to severe lifting of the cartilage. Live-animal scores for leg soundness were not in agreement with dissection data; approximately half the boars with moderate to severe joint damage were scored as sound in the visual appraisal immediately before slaughter. There was some evidence that the degree of damage increased with

increasing growth rate and length of the confinement period.

Meats Research

Beef carcass studies. Carcass studies with 438 bulls and steers sired by Charolais, Limousin, and Simmental bulls identified minor breed differences in marbling (Simmental = Limousin > Charolais; $P < 0.05$), fat depth over the rib eye (Limousin > Charolais = Simmental; $P < 0.05$), and rib eye area (Limousin = Charolais > Simmental; $P < 0.05$). There were no breed differences in objective measures of meat quality. Sex differences were substantial for all traits, bulls having less fat, greater rib eye area, and less marbling than steers ($P < 0.01$). Sex differences within breeds were considerably greater than the breed differences.

Rib roasts from all carcasses were distributed to 438 rural and urban households for consumer evaluation. Although minor breed differences were recorded for juiciness and flavor, the three sire-progeny groups scored essentially the same for the various qualities tested. Consumers found the roasts from steers more tender ($P < 0.01$) than those from bulls, an observation supported by the laboratory evidence on shear values. However, none of the roasts from bull carcasses were rated below average in tenderness. For both sexes there was no evidence of differences in overall consumer preference associated with yield grade.

Beef muscle pH. Studies involving 224 bull, steer, and heifer carcasses established that the rate and extent of postmortem pH change were specific to the muscle chosen for study. Initial pH (at 2 h post-mortem) was highest for the brachialis and lowest for the longissimus dorsi, but the change in pH up to 24 h post-mortem was greatest for the longissimus dorsi and least for the brachialis. The adductor and semimembranosus muscles were intermediate. Within sex, neither initial pH nor rate of postmortem pH change was a useful predictor of ultimate tenderness or water-holding capacity. However, approximately 30% of the bull carcasses exhibited a relatively slow rate of postmortem pH change and their shear values were generally lower (that is, the meat was more tender).

Pork quality in relation to carcass muscling. Subjective color-structure scoring applied to 460 pig carcasses identified 11% as PSE (pale, soft, exudative) and 3% as DFD

(dark, firm, dry). Lower desirability was associated with lower ultimate pH, less marbling, higher shear values (less tender meat), and lower water-binding capacity. Average color-structure scores tended to decrease (to show less desirable quality) as the ratio of muscle to bone increased; however, the correlation was negligible (-0.06), as were all correlations between the degree of muscling and objective measures of quality. It was concluded that considerable genetic improvement in lean yield could be obtained by performance selection without causing a concomitant regression in lean quality.

Beef carcass grading. A study of 100 beef carcasses undertaken in cooperation with the Production and Marketing Branch, and with assistance from packer and retail representatives, provided evidence that carcass type had a minor influence on potential retail value of carcasses graded A1. Beef-type carcasses produced approximately 2% more trimmed lean cuts (61.7 vs. 59.5%), less lean trim (17.8 vs. 18.5%), more fat trim (4.3 vs. 4.0%), and less bone (15.8 vs. 17.5%) than carcasses classified by retail representatives as dairy type. In terms of total retail carcass value, there was a difference of 2.8% in favor of the beef-type carcass. Differences in value associated with carcass weight were approximately 1% in favor of lighter carcasses (300–350 kg). Neither weight nor type of carcass influenced the relative proportions of low- and high-priced cuts. Linear measurements made on the carcasses indicated that dairy-type carcasses were longer and had longer legs, greater chest depth, and less thickness of round. The greater skeletal measurements of these carcasses were reflected in the higher percentage of bone observed for this type.

PLANT BREEDING AND PATHOLOGY

Cereal Crops

Correlations among seed characteristics in oats. The relationships among five characteristics of 35 random lines in the F_8 of each of five crosses of oats (*Avena sativa* L.) were examined. Kernel weight and kernel plumpness were positively correlated ($r = .680$ and $.764$ in 1971 and 1972 respectively), but they were not closely related to test weight, number of bosom kernels, or hull percentage.

The last three characteristics were not interrelated. There was a wide range for each characteristic among lines of each cross.

The proportion of hull was 5.5% higher on primary than on secondary kernels drawn from 15 samples taken at random from the five crosses.

Progress in oat improvement. In replicated preliminary trials at two locations, 13% of the lines tested gave yield 10 to 20% higher than that of Random (possibly the highest-yielding cultivar in Western Canada). One-third of these lines matured in the same time as Random, and although straw strength was not as great, it was adequate for some areas of oat production. Two of the 13 crosses evaluated, Forward/Pendek and Random/Forward, produced most of the high-yielding lines. All lines were evolved by the random (Kaufmann) method of breeding.

The climatic season in 1973 was ideal for evaluating lodging resistance in breeding lines. Lines from the cross Fundy/CD5924(328-52)//Pendek were superior to Pendek in straw strength and equal to Random in maturity. Lines from the cross CD157/Rodney(324-4)//Pendek were superior to Random in maturity and straw strength. Plant height of most lines was less than in either Random or Pendek.

Differential effect of common root rot on the yield of barley cultivars. The calculated yield loss from root rot was much greater in Gateway than in nine other cultivars when plants were classified according to the extent of lesions in the subcoronal internode. The yields of Bonanza, Centennial, and Jubilee were least affected by root rot.

Forage Crops

Norlac red clover licensed. Norlac, a single-cut red clover cultivar developed at Lacombe, was licensed in 1973. Forage yields are about the same as for Altaswede, but seed yields averaged 30% higher in tests at Beaverlodge and Lacombe, Alta., and Melfort, Sask. Norlac has shown greater resistance than Altaswede to northern anthracnose, caused by *Kabatiella caulivora* (Kirchn.) Karak.

Effect of seeding rates on yield and composition of oats for forage. Based on averages of six cultivars tested for 3 yr in replicated trials, forage yields of oats (silage stage) were 9,980, 10,210, and 9,980 kg/ha when

the seeding rates were 38, 67, and 95 kg/ha. The seed accounted for 53.5% of the dry weight, the stem and leaf sheath 39.0%, and the leaf blade 7.5%. These percentages were not influenced by the rate of seeding. Grain yields taken from plots contiguous to those harvested for forage were 5,280, 5,430, and 5,290 kg/ha for seeding rates of 38, 67, and 95 kg/ha.

Forage disease survey. In 1972, for the third consecutive year, a forage crop disease survey covering eight species and 34 diseases was carried out in central and northern Alberta. Grasses sustained somewhat less loss than legumes, with the overall loss estimated at more than 6%, or \$5.4 million, due to foliage diseases.

Diseases of wild rye and other grasses. The intensity of powdery mildew, spot blotch, and leaf rust on various lines and species of *Elymus* (wild rye) was assayed in the field and resistance determined. Fifteen previously unreported diseases of *Elymus* and other forage grasses were identified as well as commonly occurring diseases.

Rapeseed growth stages. A growth-stage key of leaves, buds, flowers, pods, and seed of the rapeseed plant was developed to allow accurate determination of the various stages of its growth. This key was useful in the cooperative survey of diseases.

Herbicide increases stem rot. Field observations in 1972 strongly suggested that the herbicide barban increased the incidence of stem rot caused by *Sclerotinia sclerotiorum* (Lib.) de Bary in rape. In a subsequent greenhouse study, significant differences in the numbers of plants affected by stem rot were found between flats of rape sprayed with barban and unsprayed ones. It is suggested that caution should be used in recommending barban for use in rape fields with a history of stem rot.

Horticultural Crops

New tomato cultivars. Booster, Melfort, and Pembina, new cultivars from the Cooperative Tomato Breeding Project for the Prairie Provinces, reached maturity in 73 days, 6 days later than Rocket. Fruit size of Booster and Pembina ranged from 80 to 90 g, 40 g greater than in Rocket. Pembina ripened five more fruit per plant than Booster but threefold less than Rocket. Melfort produced the largest fruit, averaging 126 g,

but there was a tendency toward an undesirable degree of fasciation; 12% of the fruits were unmarketable because of this factor.

CROP MANAGEMENT AND SOILS

Weed Research

Herbicides applied postemergence to barley and wheat to control wild oats. AC 84777 (Cyanamid of Canada Ltd.), sprayed at either 0.56 or 1.12 kg/ha when wild oats were in the three- to five-leaf stage of growth, gave 75 to 90% control of the weed in Galt barley and Park wheat in 3 yr of tests. The degree of control increased as the spray date was delayed toward the five-leaf stage. However, the crop yield was lower at the later spray date because of the longer period of weed competition. When the herbicides 2,4-D, MCPA, and a 1:1 mixture of bromoxynil and MCPA were tank mixed with AC 84777, they controlled both wild oats and a number of broad-leaved weed species. Barley proved to be highly tolerant of these treatments in all tests but there was injury to wheat in one test in 1972.

AC 84777 has been recommended for control of wild oats in barley by the Canada Weed Committee (Western), and registration is being sought by the company under the trade name "Avenge."

Studies with ring-labeled ^{14}C AC 84777 showed that the compound moved very readily in the xylem, that is, toward the leaf tips, of the wild oats but little or no mobility was evident in the phloem. Because of this, thorough spray coverage is essential for control.

In 1973, mixtures of AC 84777 with barban appeared very promising for control of wild oats in barley, in that the mixture applied at the earlier two- and three-leaf stages was more effective than either compound used alone. Similarly, mixtures of Endaven (Shell Canada Ltd.) with barban showed to advantage for the control of wild oats in wheat.

Herbicide kills quack grass rhizomes. Roundup (Monsanto Canada Ltd.) as a directed spray at 1.12 kg/ha killed both the top growth and the rhizomes of quack grass grown in the greenhouse in 1972 and 1973. The herbicide applied on single shoots growing from rhizome sections 0.5 m long moved at lethal levels through the entire rhizome

sections. Similar treatments at rates up to 4.48 kg/ha on Canada thistle were equally effective in killing shoots but significantly less so in killing roots. Barley, oats, and wheat, planted in the same flats immediately before spraying or up to 2 wk after, showed no effects from the herbicide.

In field experiments in the same 2 yr, Roundup applied at 1.12 kg/ha on May 15, when the quack grass was 12 cm tall, and followed by rototilling and seeding of barley at 1-, 2-, and 3-wk intervals after spraying reduced the quack grass stand by as much as 90%. The reduction in competition for the quack grass resulted in highly significant increases in the yield of barley. Control of the quack grass was somewhat higher when the interval between spraying and tillage was at least 2 wk.

In another test on undisturbed quack grass sod, Roundup gave more complete control when spraying was delayed until the flag-leaf and early-boot stages than earlier. However, when spraying was delayed until heading and flowering, the dosage had to be doubled (to 3.36 kg/ha) to effect similar control. These late spray dates preclude the use of the material as a preplant treatment for spring-sown grains.

In field studies, Roundup on Canada thistle showed a similar pattern of control and increased barley yields. Better destruction of roots again resulted from spraying plants that had advanced to the bud and early flowering stages.

Control of chickweed in barley. Mecoprop at 0.84 kg/ha has given excellent selective control of chickweed in cereal crops but is rather expensive. Dicamba, although less costly, has not given as consistently good control. A mixture of mecoprop with dicamba in the ratio of 4:1 (0.420 + 0.105 kg/ha) has given very good control of this weed at significantly less cost.

Competition of wild oats in rapeseed. Extensive tests have established the competitive index for wild oats in rape at 0.0245. Loss, in g/m^2 , equals $ab_1\sqrt{x}$, where a equals expected weed-free yield (g/m^2), x the number of wild oats/ m^2 , and b_1 the "index of competition." The index is 0.0230, 0.0339, and 0.0601 for barley, wheat, and flax. Thus, rape is more successful than wheat and flax, and less successful than barley, in competing with wild oats.

Soils

N fertilization and oil content of rape. In tests for 3 yr, 1971–73, fertilization with N up to 168 kg/ha did not significantly reduce the oil content of Span rape, although it tended to do so. The 10-test average oil contents were 40.4, 39.8, 39.6, 39.1, 39.3, and 38.4% with N at 0, 34, 67, 101, 134, and 168 kg/ha. Oil production quantities at the increasing levels of N were 470, 530, 620, 650, 660, and 670 kg/ha.

Placement of N fertilizer for barley. At 4 of 15 soil sites tested in 1973, N broadcast at 67 kg/ha was not as effective in increasing barley yields as was the same amount of N banded close to the seed, or half the amount of N placed with the seed and the other half banded. Average yields obtained at the four test sites were, with all N broadcast, 1,480 kg/ha; with all N banded, 2,420 kg/ha; and with the split application of N, 2,490 kg/ha. Average yields for the same treatments at the other 11 test sites were 2,610, 2,650, and 2,460 kg/ha.

Plant symptoms and plant analysis suggest that the four soils were deficient in plant-available Mn, and where N was concentrated near or with the seed the availability of Mn was increased.

Nutrient deficiencies and barley root rot. Correction of a deficiency of N and P in a stubble field reduced that percentage of severely and moderately lesioned barley plants and the yield loss from root rot. On an adjacent fallow field that had adequate levels of both N and P, addition of either or both did not change the disease rating or the yield loss from root rot. Averaged for nine varieties, yield losses for fallow – no fertilizer were 13.4%; fallow – NP fertilizer, 11.5%; stubble – no fertilizer, 35.8%; and stubble – NP fertilizer, 28.7%.

SOLONETZIC SOIL SUBSTATION, VEGREVILLE

Effects of salt solutions on a Chernozemic soil. A study was conducted to determine the relative effects of neutral and alkaline salts on water penetration, soil dispersion, and

soluble salt distribution within columns of a Chernozemic soil. Dilute solutions (0.01 N and 0.1 N) of Na_2SO_4 and Na_2CO_3 , and water for comparison, were allowed to penetrate the columns, which were then subjected to the penetration of water. The salts were about equally effective at equal concentrations in dispersing the soil and blocking the subsequent entry of water. The main difference in their effects was that Na_2SO_4 caused heavy leaching of Ca^{++} , whereas Na_2CO_3 showed little such effect. Soil leached with Na_2SO_4 is as likely to become solonetzic as soil leached with Na_2CO_3 , but would probably be characterized by a layer of CaSO_4 accumulation.

Long-term effects of N fertilizers on a Solonetzic soil. The comparative effects of 10 consecutive annual applications of 112 kg/ha of N as NH_4NO_3 , $(\text{NH}_4)_2\text{SO}_4$, and NH_2CONH_2 on the chemical properties of the Ap horizon of a Solonetz soil showed that $(\text{NH}_4)_2\text{SO}_4$ lowered the pH of the soil. Associated with lowered pH was a loss of Ca and Mg, which amounted to about half the exchangeable content of the untreated soil. It would be costly to replenish the Ca supply on Solonetzic soils in Western Canada, where limestone must be transported long distances.

Influence of ammonium on the behavior of clay particles. The addition of ammonium salts increased the hydraulic conductivity of a Solonetzic Bnt horizon. The improved conductivity was caused by an increase in the salt concentration of the soil solution and by the ammonium adsorbed on the clay particles. Because the dominant clay mineral in this soil type is montmorillonite, purified bentonite was used for comparative studies. Studies of mobility in montmorillonite systems indicated that the adsorbed NH_4 ions are tightly bound to the clay particles. The size of the NH_4 -tactoids was found to be larger than that of the Na-tactoids but less than half that of the Ca-tactoids. It was concluded that the beneficial effect of ammonium on water movement in Solonetzic soils is less than that of Ca, but the transformation of the adsorbed ammonium in the field, followed by replacement of sodium by hydrogen, may result in further improvement of these soils.

PUBLICATIONS

Research

- Berkenkamp, B. 1973. Disease assessment and losses in forage crops in central and northern Alberta, 1972. *Can. Plant Dis. Surv.* 53:11-15.
- Berkenkamp, B. 1973. A growth-stage key for rape. *Can. J. Plant Sci.* 53:43.
- Berkenkamp, B. 1973. Qualitative assays of ribonuclease produced by plant pathogens. *Can. J. Microbiol.* 19:1431-1434.
- Berkenkamp, B., Folkins, L. P., and Meeres, J. 1973. Diseases of *Elymus* and other grasses in Alberta, 1972. *Can. Plant Dis. Surv.* 52:36-38.
- Berkenkamp, B., and Friesen, H. A. 1973. The effect of barban on stem rot of rape. *Can. J. Plant Sci.* 53:917.
- Cairns, R. R., and Szabolcs, I. 1973. The effect of sodium sulfate and sodium carbonate solutions on chemical and physical properties of Chernozem soil. *Can. J. Soil Sci.* 53:399-403.
- Friesen, H. A., and Bowren, K. E. 1973. Factors affecting the control of wild oats in rapeseed with trifluralin. *Can. J. Plant Sci.* 53:199-205.
- Newman, J. A., Rahnefeld, G. W., and Fredeen, H. T. 1973. Selection intensity and response to selection for yearling weight in beef cattle. *Can. J. Anim. Sci.* 53:1-12.
- Piening, L. J. 1973. Differential yield response of ten barley cultivars to common root rot. *Can. J. Plant Sci.* 53:763-764.
- Walkof, C., Anderson, R. H., and Allen, H. T. 1973. Three bush-type tomato cultivars: Melfort, Booster, and Pembina. *Can. J. Plant Sci.* 53:643-644.
- Fredeen, H. T. 1973. Agricultural science publication—a Canadian viewpoint. *N.Z. J. Agric. Sci.* 7:98-99.
- Fredeen, H. T. 1973. Animal science research policy in Canada. *Proc. 4th Annu. Anim. & Poult. Sci. Seminar, Univ. of B.C.* pp. 1-16.
- Fredeen, H. T. 1973. Effects of crossbreeding. *Canadex* 420.41.
- Fredeen, H. T. 1973. Growth potential of the Canadian pig industry. 1. Potential for growth through breeding and genetics. *Proc. Can. Soc. Anim. Sci. Annu. Meet.* pp. 34-43.
- Fredeen, H. T., Bradley, J. A., and Muir, K. 1973. Joint damage in boars reared under confinement. *Can. J. Anim. Sci.* 53:770. (Abstr.)
- Friesen, H. A. 1973. Glyphosate kills couchgrass rhizomes. *Weed Sci.* (Abstr.) p. 12.
- Friesen, H. A. 1973. *Roundup* for quack grass. *Canadex* 641.
- Friesen, H. A. 1973. Identifying wild oats yield losses and assessing cultural control methods. *Can. Dep. Agric. Seminar on Wild Oats, Saskatoon.* pp. 20-26.
- Friesen, H. A. 1973. Treflan controls weeds in rapeseed. *Can. Agric.* 18(1):30-31.
- Friesen, H. A. 1973. Herbicides popular in Western Canada. *Weeds Today* 4:20-22.
- Friesen, H. A., and Dew, D. A. 1973. FX 2181 and AC-84,777 for postemergence control of wild oats in wheat and barley. *Proc. North Cent. States Weed Conf.* 27:39-41.
- Martin, A. H., and Fredeen, H. T. 1973. Consumer acceptability of beef in relation to breed cross and yield category. *Can. J. Anim. Sci.* 53:770. (Abstr.)
- Newman, J. A., Weiss, G. M., and Schrader, B. 1973. Comparisons of Hereford-cross calves by South Devon, Maine-Anjou, and Simmental sires for beef production traits. *Can. J. Anim. Sci.* 53:768. (Abstr.)
- Toogood, J. A., and Cairns, R. R., eds. 1973. *Solonetzic soils technology and management.* Bull. B-73-1. 1st ed. Univ. of Alta., Edmonton, Alta.

Miscellaneous

- Berkenkamp, B. 1973. A three-year survey of losses from forage foliar diseases in central and northern Alberta. *Forage Notes* 18:3-5.
- Cairns, R. R. 1973. Deep plowing of Solonetz soils. *Can. Agric.* 18(3):30-31.
- Cairns, R. R. 1973. Fertilizing crops on Solonetz soil. *Canadex* 530.
- Fredeen, H. T. 1973. Publish or perish. *Hortic. Sci.* 8:160-161.

Research Station Lethbridge, Alberta

PROFESSIONAL STAFF

J. E. ANDREWS, B.S.A., M.S., Ph.D.	Director
I. L. STEVENSON, B.S.A., M.S.A., Ph.D.	Associate Director
S. B. ARNASON, B.S.A.	Head, Administration Section
C. G. SCHOENING	Administrative Officer—Accounts

Scientific Support

P. E. BLAKELEY, B.S.A., M.Sc.	Technical Liaison Officer
G. C. R. CROOME, B.A., M.Sc.F.	Editor
G. C. KOZUB, B.Sc., M.Sc.	Biometrician
J. P. MISHA, B.L.S.	Library Area Coordinator
K. C. PIEUK (Mrs.), B.A., M.L.S.	Assistant Librarian

Economics Section

B. H. SONNTAG, B.S.A., M.Sc., Ph.D.	Senior Economist
K. K. KLEIN, ¹ B.S.A., M.Sc.	Economist
K. D. RUSSELL, B.Sc., M.S.	Economist

Animal Science Section

S. B. SLEN, B.A., B.Sc., M.S., Ph.D.	Head of Section; Animal production
C. B. M. BAILEY, B.S.A., M.S.A., Ph.D.	Animal physiology
D. M. BOWDEN, B.S.A., M.S.A., Ph.D.	Animal nutrition
K.-J. CHENG, B.Sc., M.Sc., Ph.D.	Rumen microbiology
E. E. GARDINER, ² B.S., M.S., Ph.D.	Poultry nutrition
R. HIRONAKA, B.Sc., M.Sc., Ph.D.	Animal nutrition
J. E. LAWSON, B.S.A., M.S.A.	Beef cattle breeding
J. A. P. VESELY, B.S.A., M.S.A., Ph.D.	Sheep and dairy cattle breeding

Crop Entomology Section

N. D. HOLMES, B.Sc., M.Sc., Ph.D.	Head of Section; Wheat stem sawfly
W. A. CHARNETSKI, B.Sc., M.Sc., Ph.D.	Insecticide residues
A. M. HARPER, B.Sc., M.Sc., Ph.D.	Aphids
G. A. HOBBS, B.S.A., M.Sc., Ph.D.	Forage-crop insect pollinators
R. KASTING, B.Sc., M.Sc., Ph.D.	Plant and insect biochemistry
C. E. LILLY, B.Sc., M.Sc.	Potato and sugarbeet insects
S. McDONALD, C.D., B.Sc., M.Sc.	Toxicology
D. L. STRUBLE, B.A., M.A., Ph.D.	Insect attractants; insecticide residues
G. E. SWAILES, B.S.A., M.S., Ph.D.	Cutworms and special crop insects

Plant Pathology Section

J. B. LEBEAU, B.Sc., M.S., Ph.D.	Head of Section; Forage and turfgrass diseases
T. G. ATKINSON, ³ B.S.A., M.Sc., Ph.D.	Cereal diseases
F. R. HARPER, B.Sc., M.Sc., Ph.D.	Vegetable diseases
E. J. HAWN, D.F.C., B.S.A., M.Sc., Ph.D.	Nematode diseases
G. A. NELSON, B.Sc., M.Sc., Ph.D.	Bacterial diseases
D. W. A. ROBERTS, B.A., Ph.D.	Cryobiology

Plant Science Section

D. B. WILSON, B.Sc., M.S., Ph.D.	Head of Section; Irrigated pastures
J. R. ALLAN, B.Sc., M.A., Ph.D.	Aquatic plant physiology
S. FREYMAN, ⁴ B.Sc., M.S.A., Ph.D.	Crop physiology
M. N. GRANT, B.Sc., M.Sc., Ph.D.	Winter wheat breeding
M. R. HANNA, ⁵ B.S.A., M.S.A., Ph.D.	Forage legume breeding
A. JOHNSTON, B.S.A., M.S.	Range ecology
M. S. KALDY, B.Sc., M.S., Ph.D.	Food science
G. A. KEMP, B.Sc., Ph.D.	Vegetable breeding
R. I. LARSON (Miss), B.A., M.A., Ph.D.	Wheat cytogenetics
M. D. MACDONALD, B.Sc., Ph.D.	Corn breeding; wheat cytogenetics
H. MCKENZIE, B.S.A., M.Sc., Ph.D.	Spring wheat breeding
N. B. McLAUGHLIN, B.Sc. (Eng.), M.Sc.	Forage systems engineering
J. J. SEXSMITH, B.Sc., M.Sc.	Crop weeds
S. SMOLIAK, B.Sc., M.S.	Dryland pastures; grass breeding
W. E. TORFASON, B.S.A., M.Sc., Ph.D.	Vegetable culture
S. A. WELLS, B.S.A., M.Sc., Ph.D.	Barley breeding

Soil Science Section

D. C. MACKAY, B.Sc., M.S., Ph.D.	Head of Section; Plant nutrition
D. T. ANDERSON, ⁶ B.S.A., M.Sc.	Agricultural engineering
J. B. BOLE, B.S.A., M.Sc., Ph.D.	Plant nutrition
J. M. CAREFOOT, B.S.A., M.S.A.	Chemical analyses
J. F. DORMAAR, B.S.A., M.S.A., Ph.D.	Organic chemistry
S. DUBETZ, B.Sc., M.S.	Irrigation agronomy

E. H. HOBBS, B.Sc. (Eng.)
 K. K. KROGMAN, B.Sc., M.Sc.
 L. E. LUTWICK, B.Sc., M.Sc., Ph.D.
 J. L. NEAL, B.S., M.S., Ph.D.
 M. OOSTERVELD, B.Sc. (Eng.), M.Sc.
 U. J. PITTMAN, B.Sc.
 A. D. SMITH, B.Sc.
 T. G. SOMMERFELDT, B.Sc., M.S., Ph.D.
 J. C. VAN SCHAİK,⁷ M.Sc., Ph.D.

Irrigation engineering
 Irrigation efficiency
 Chemistry and genesis
 Soil microbiology
 Hydrology
 Dryland agronomy
 Dryland forages
 Drainage engineering
 Soil physics

Veterinary-Medical Entomology

W. O. HAUFE, B.A., M.Sc., D.I.C., Ph.D.
 K. R. DEPNER, B.Sc., M.Sc., Ph.D.
 M. A. KHAN, G.V.Sc., M.S., Ph.D.
 W. A. NELSON, B.Sc., M.Sc., Ph.D.
 R. H. ROBERTSON, B.A., M.Sc.
 J. A. SHEMANCHUK, C.D., B.Sc., M.Sc.
 J. WEINTRAUB, B.A., M.S.

Head of Section; Bioclimatology
 and behavior
 Black fly ecology
 Toxicology
 Physiology (ectoparasites)
 Serology
 Biting fly ecology
 Cattle grub ecology

Departures

C. W. LINDWALL, B.Sc.
 Resigned October 1, 1973
 D. S. SMITH, B.Sc., M.S., Ph.D.
 Retired December 27, 1973
 P. H. WALKER, C.D., B.Sc.
 Retired May 31, 1973
 D. H. WHITFIELD
 Resigned October 12, 1973
 P. R. WILKINSON, B.A., M.A., Ph.D.
 Transferred April 24, 1973, to Canada Health and
 Welfare, Ottawa
 R. P. J. ZENTNER, B.S.A.
 Resigned August 31, 1973

Agricultural engineering
 Grasshopper ecology and survey
 Editor
 Administrative Officer—Personnel
 Ticks and economic entomology
 Economist

VISITING SCIENTISTS

J. R. ANDERSON, B.S., M.S., Ph.D., 1973-74
 Sabbatical from University of California, Berkeley,
 California
 LILIA ALBERT DE MARQUEZ, Ph.D.
 Transfer of work from Centro de
 Investigacion de Estudios Avanzados del Instituto
 Politecnico Nacional, Mexico

Blood-sucking flies
 Methods for insecticide residue
 analysis

National Research Council postdoctorate fellow

D. G. KELLER, B.S., M.S., Ph.D.

Beef cattle breeding

Canadian International Development Agency transfers

B. R. HEGDE, M.Sc., Ph.D.

Crop physiology

R. P. SINGH, M.Sc., Ph.D.

Agronomy

S. M. VIRMANI, M.Sc., Ph.D.

Biometeorology; plant nutrition

¹On educational leave, Purdue University, West Lafayette, Indiana, from August 1973 to July 1976.

²On transfer of work to Poultry Research Centre, Edinburgh, Scotland, from July 1973 to June 1974.

³On transfer of work to Rothamsted Experimental Station, Harpenden, England, from September 1973 to September 1974.

⁴Seconded to Indo-Canadian Dryland Research Project, Hyderabad, India, from December 1973 to December 1975.

⁵On transfer of work to Research Institute for Cereals and Industrial Crops, Fundulea-Bucharest, Romania, from April 1972 to March 1973.

⁶Seconded to Indo-Canadian Dryland Research Project, Hyderabad, India, from January 1971 to April 1974.

⁷On transfer of work to University of Arizona, Tucson, Arizona, from December 1973 to March 1974.

INTRODUCTION

The Research Station at Lethbridge conducts a broad research program related to dryland and irrigated agriculture and to livestock production.

Scientists, representing a wide range of disciplines and functions as shown in the staff listing, are integrated into multidisciplinary mission-orientated program groups with particular emphasis on the breeding and management of legumes, grasses, cereals, oilseeds, and horticultural and special new crops; nutrition, management, and breeding of beef, dairy cattle, and sheep; soil and crop management; resource conservation and erosion control; biological disposal of crop and animal wastes; management of pesticide residues; assessment of crop and animal losses from pests; control of economically important diseases of crops; and control of insect pests of crops and animals. Economists seconded from the Economics Branch are integrated into the research programs to assist in the planning of research, the evaluation of research results, and to facilitate the extension of this information to the farm community.

Results of particular interest during the year include establishment of the importance of salt concentration and size of particle in diets for controlling feedlot bloat; discovery of a synthetic sex attractant for the army cutworm; repeated evidence that the pin nematode does not cause "alfalfa sickness"; release of Hector, a new two-rowed barley suitable for malting; improvement of cultural methods for corn to give grain yields of up to 6.3 t/ha (100 bu/ac); establishment of nonpolluting irrigation practices with sewage effluent for forage production; production of high-protein wheat (18–20%) by applying high levels of N fertilizer; and confirmation that a simple magnetic treatment of seed can increase cereal production by 7–16%. The results of our research programs are summarized in this report.

The Station continues to maintain close liaison with the Alberta Department of Agriculture and grower and producer organizations in the application of its research results. Our staff conducted a feasibility study for the province in cooperation with provincial agencies to assess approaches to the control of black flies in northern municipalities concerned with the expansion of livestock production. Research personnel continue to participate actively on federal-provincial committees, workshops, and courses concerned with provincial and local agricultural problems.

Detailed information on research results can be obtained from the scientists or from the publications listed in this report. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta. T1J 4B1.

J. E. Andrews
Director

ANIMAL SCIENCE

Sheep

Urinary excretion of 11-deoxy 17-ketosteroids in ram, cryptorchid, and wether lambs. One 24-h urine sample was collected from each of 33 ram, 37 cryptorchid, and 31 wether lambs before slaughter and tested for 11-deoxy 17-ketosteroids in order to relate sex differences to flavor and growth rate. On the average, wethers produced about two-thirds ($598 \mu\text{g}$) and cryptorchids about one-third ($371 \mu\text{g}$) of the amount of androstosterone and etiocholanolone produced by rams ($929 \mu\text{g}$). The amounts of dehydroepiandrosterone excreted by ram, cryptorchid, and

wether lambs were 191, 102, and $163 \mu\text{g/day}$. The means, however, were not significantly different because of the high variation within each sex-group. These steroids increased growth rate significantly ($P < 0.05$).

Skinning time for ram and wether lambs. Meat processors have long claimed that ram lambs take longer to skin than wethers. To confirm this claim experimentally, lambs representing four different breed crosses, with an unweighted average carcass weight of 27.0 ± 3.5 (SD) kg, were skinned at a commercial slaughterhouse. The unweighted average time needed to skin a carcass was 18.2 ± 30.3 (SD) sec. Ram lambs took an average of 30 sec longer to skin than wether

lambs ($P < 0.001$) but there were no significant differences in skinning time among the four breed crosses. The regression coefficient of skinning time on carcass weight, 2.4 sec/kg, was highly significant ($P < 0.01$).

Beef Cattle

Blood metabolites as indicators of energy status of cows. Aberdeen Angus and Hereford heifers restricted to low intakes of energy during the last 3 mo of pregnancy had lower blood glucose and higher plasma ketones and nonesterified fatty acids (NEFA) than heifers not so restricted. Plasma NEFA levels responded more to differences in energy intake than did levels of blood glucose or plasma ketones. Changes in levels of glucose, ketones, and NEFA may prove to be useful indices of energy requirements during late stages of pregnancy.

Nutrient utilization by female beef cattle. The total digestible energy consumed by 2-yr-old Jersey \times Angus crossbred heifers and their calves was about 9% less per kilogram of calf weaned than for large crossbred heifers (Hereford \times Angus, Simmental \times Angus, and Charolais \times Angus) and their calves. For each kilogram of gain from 60 days of age to weaning, calves of Jersey \times Angus heifers consumed an average of 0.54 kg of a pelleted creep feed, whereas calves of Simmental \times Angus consumed 0.68 kg, and those of Hereford \times Angus and Charolais \times Angus consumed 0.73 kg. Measurements of milk production and quality at 6, 14, and 22 wk after calving indicated that the calves of those heifers producing more energy in their milk consumed less creep feed per unit of weight gain from birth to weaning.

Compensatory gain. Reduced growth rate of steers restricted in feed intake for 12 or 24 wk was followed, after the steers were returned to full feed, by faster growth rates than in steers that were full-fed throughout. The period of faster growth did not fully compensate for the earlier restriction and an extra 68 days were required to reach market weight (298 vs. 230 days). Total feed consumed was similar for all groups despite the differences in length of feeding period. This may be explained by the higher fat content of carcasses from nonrestricted steers (60% graded overfat) compared with those from restricted steers (7% graded overfat). Though an all-concentrate diet was fed to both

groups, only 6% of the livers from the steers were abscessed compared with an average of about 30% among commercial feedlot steers fed similar diets.

Feed particle size and bloat. Steers fed a coarse-particle diet, which reduced feedlot bloat, gained 0.11 kg/day (0.25 lb) more than steers fed a fine-particle diet of the same composition. Based on 250 days of feeding, this amounted to over 27 kg (60 lb) of extra gain for cattle on the coarse diet.

Salt intake and bloat. Increasing the NaCl level in a fine-particle concentrate diet from 0.5% to 4% reduced the frothy condition and carbohydrate content, lowered the viscosity, and increased the pH of the rumen fluid. Examination by electron microscopy of rumen contents from cows fed a low-salt diet showed massive lysis of bacteria and formation of extensive extracellular slimes, both of which may contribute to the conditions associated with bloat. Further observations indicated that, when bloat was prevented by increasing the NaCl level in a diet, bacterial lysis and slime formation were reduced. The addition of NaCl and the use of coarse-particle diets provide a practical means of preventing feedlot bloat.

Rumen microbiology. Cell lysis and the spontaneous formation of spheroplasts were observed in stationary phase cultures and in aging cultures of *Bacteroides ruminicola*. *Megasphaera elsdenii*, an anaerobic rumen bacterium that has been implicated as one of the agents responsible for feedlot bloat, produced intracellular glycogen granules to the extent of 17% of the dry weight of the cells. Of the three species of anaerobic gram-negative rumen bacteria studied, *Bacteroides ruminicola*, *B. succinogenes*, and *Megasphaera elsdenii*, only *B. ruminicola* produced significant amounts of alkaline phosphatase. This enzyme is firmly bound to a structural component within the periplasmic area of the cell wall. The alkaline phosphatase level of *B. ruminicola* and *B. succinogenes* can be a useful criterion for differentiating these two species.

Poultry

Linseed oil tended to be superior to animal tallow in supporting chick growth and decreasing the amount of feed required, although previously it was not considered suitable for poultry feed. To study further

the potential of linseed oil as an energy source, the fatty acid composition of breast muscle from 4-wk-old birds was determined. The fatty acid composition of the tissue was found to reflect the fatty acid composition of the fat or oil being fed.

CROP ENTOMOLOGY

Aphids

The English grain aphid, although it often appears in large numbers on wheat heads in late summer, has not been considered economically important in the past. Tests have now shown that an infestation averaging 76 aphids/head can reduce by 8% the weight of kernels from the infested heads. Dimethoate at 210 ml/ha (3 oz/ac) gave adequate control of this species and, on the basis of preliminary results, left only 0.03 ppm dimethoate and 0.03 ppm dimethoxon on the heads 21 days after application.

Cabbage Root Maggot

Maggots collected in the Edmonton area in 1972 were tested in the laboratory in 1973 and found to be more resistant to dieldrin than those collected and tested in 1967. Although the use of dieldrin was discontinued in 1965, the residues in the soil had evidently continued to select more resistant flies.

Cutworms

The pale western and the redbacked cutworm, which were more abundant than in 1972, severely damaged wheat, barley, and other crops.

Two new insecticides, chlorpyrifos and leptophos, were as effective as endrin in controlling the pale western cutworm when applied to wheat plants but not when applied to bare soil. Leptophos applied at the recommended rate to wheat seedlings was not detected in the kernels of the mature plants, but the straw harvested 63 days after application contained up to 0.07 ppm leptophos, 0.01 ppm of its phenol metabolite, and no detectable levels of the oxygen analogue.

A laboratory assay showed that female moths of the army cutworm produce a sex pheromone. Tests with synthetic compounds produced one that elicited a strong response from the males in the laboratory and also attracted males to traps in the field.

Field studies with traps baited with virgin females of the redbacked cutworm showed that they begin to produce their sex pheromone when they are 2 days old. Males were caught in the traps until late September; this is much later than previously shown by other methods of detection.

Grasshoppers

Grasshoppers continued to be a major threat to crops in Alberta on an area of about 64,750 km² (25,000 sq miles). The migratory grasshopper predominated in most areas, and the clearwinged grasshopper was the major species in a few localities.

In laboratory studies, the oral toxicity of eight new insecticides equaled or exceeded that of dimethoate for the twostriped and the migratory grasshopper.

Pollinating Insects

We have returned to the use of wooden nests for the alfalfa leafcutter bee because various remedial measures have not prevented mold from developing in the cells in polystyrene nests.

Selection for the third year has produced a strain of the alfalfa leafcutter bee that is 99.3% univoltine. Bivoltine bees suffer because the second generation is often unable to produce viable offspring before the end of the growing season, thus reducing the numbers surviving to the next year.

Potato Insects

Three insecticides, chlorpyrifos, diazinon, and BAY 92114 (Chemagro Corporation), applied in the row at 2.24 kg/ha effectively protected potatoes against the prairie grain wireworm. Chlordane, which is registered for this use, was inferior.

Larvae and adults of the Colorado potato beetle were effectively controlled with registered insecticides used at one-quarter the recommended rate when the spray was applied properly.

Rape Insects

The major pests in 1973 were the bertha armyworm, the alfalfa looper, the flea beetles, and the painted lady. Damage by the bertha armyworm was much less than in 1972.

The effectiveness of carbofuran as a control for flea beetles was confirmed. Yields

from untreated plots were one-sixth of those treated with carbofuran.

Some mature larvae of the bertha armyworm detoxified methomyl and carbofuran, indicating that continued use of these compounds is likely to produce resistant strains of the armyworm. Insecticides already registered for other insects on rape effectively controlled larvae of the alfalfa looper and the painted lady.

The mixture of the synthetic compounds that elicited strong responses from males of the bertha armyworm in the laboratory was only partially effective in the field, and none of the compounds in pure form was effective. Cages developed for field tests of pheromones of the bertha armyworm were baited with virgin females and set out at various locations in southern Alberta. The adults were found to be more widely distributed than previously shown by other detection methods.

Rape Residue Phytotoxin

Argentine and Polish rape both contain the phytotoxin at all stages of growth from 12 days after germination to seed formation. The application of commercial fertilizers had variable effects on the quantities of phytotoxin in the plants. Wheat cultivars vary in their susceptibility to the phytotoxin, indicating that selection for resistant wheats is possible.

Sugarbeet Insects

The insecticide aldicarb was as effective as carbofuran and more effective than carbophenothion for the control of the sugarbeet root maggot. Fonofos was extremely phytotoxic. Control of the maggot prevented losses of up to 19.5 t/ha.

Insecticide Residues

Residues of organochlorine insecticides were found to be widespread in irrigated soils south and east of Lethbridge. Dieldrin was present in 97% of the samples, heptachlor epoxide was present in 93%, and DDT in 85% of the samples. The levels of residue, however, did not exceed 0.05 ppm for dieldrin or heptachlor epoxide, or 0.19 ppm for *p,p'*-DDT. Residues of organophosphorus insecticides were not detected.

ECONOMICS

Production of Alfalfa Seed Using Leafcutter Bees

The economic feasibility of producing alfalfa seed on dryland and irrigated land was studied. Data from experiments conducted at the Station, producer surveys, and other sources were used to estimate costs of seed production. Based on 1972 input prices, production costs were estimated at 62–66¢/kg (28–30¢/lb) for cleaned alfalfa seed on both dryland and irrigated land.

Derivation and Evaluation of Rations for Feeder Cattle

Data from an experiment on compensatory gains in the feedlot were used to develop a linear programming model that simultaneously selects an optimal feeding program and formulates a least-cost ration for a given set of prices for feedstuffs and slaughter steers. Results from the model indicate that restricted feeding to improve carcass quality is an economically justifiable practice, given the price differentials among grades that have prevailed since the inception of the new grading standards for beef.

Economics of Producing Irrigated Cash Crops

A set of yield response surfaces for several important irrigated crops was developed. These response surfaces are based on historical data on yield responses to N, P, and water inputs. A linear programming model that selects optimal combinations of crops and input levels for alternative resource and price situations given these response surfaces has been developed.

Development of Simulation Models for Planning Farm Business

Simulation models that are being developed as tools to aid in the economic evaluation of research results were used by the Economics Branch in a study on domestic feed grain marketing policy. The models were used to measure the effects of alternative levels of feed grain and livestock prices and various levels of feed grain price stability on level of income, stability of income, and net worth of farms that differed in size, location, and enterprise mix.

PLANT PATHOLOGY AND PHYSIOLOGY

Forage and Turf Diseases

Seven varieties of alfalfa and one of winter wheat were tested for resistance to winter crown rot in controlled-temperature field plots. Soil temperature was controlled at 2.5 cm below the surface to a minimum of 6, 3, 0, or -3°C throughout the winter. Varieties of *Medicago falcata* L. were the most resistant at all temperatures, and *M. sativa* L. var. Du Puits was the only variety that became infected at controlled minimum temperatures above 0°C . Resistance did not differ significantly among the varieties of winter wheat and alfalfa commonly grown in this region.

Further studies on the pin nematode in 1973 confirmed that, despite its widespread distribution in soils of central Alberta, it was of little importance as a cause of alfalfa sickness.

A dwarf *Poa*, selected for use on lawns and athletic fields, has been tested in Washington, British Columbia, Alberta, Manitoba, Ontario, and Ohio. Good evaluations were received for winterhardiness, color, density, texture, and disease resistance. An application for licensing this variety under the name Banff has been submitted to the Plant Products Division.

Cereal Diseases

Soil-borne pathogens. Current results support the view that the increased yields of Olli and Betzes barley after fumigation of field soil with Vapam (Stauffer Chemical Company) were due to reduced infection by *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur and possibly other soil-borne root pathogens.

Several techniques and procedures for growing the roots and subcrown internodes of wheat plants under axenic conditions were devised and tested. Although axenic cultures were established, it has not been possible to devise a system in which subcrown internodes are consistently long enough to rate for root-rot reaction.

Seed treatment with Vitaflo (UniRoyal Limited) reduced the incidence of bunt in Winalta winter wheat from 53% in the untreated sample to 1–2%.

Ergot in rye. In 1972 and 1973, the incidence and severity of ergot were determined in selected fields of commercial rye in

Alberta by uniform methods of survey and assessment. Ergot was present in half of the fields examined in 1972 and 35% of those examined in 1973. The disease occurred more often and was more severe in the later maturing crops examined in August than in the earlier maturing ones examined in July. Sclerotia developed in 0.17 and 0.03 heads/ m^2 in 1972 and 1973. There were 19% fewer seeds and the seeds were 25.9% lighter in ergot-affected heads than in comparable ergot-free heads. Yield loss from ergot was negligible both years.

Cold Hardening of Wheat

A semimicromethod has been developed to separate the various forms of invertase, β -glucosidase, and β -galactosidase in wheat leaves. This technique will be valuable in following the changes in these enzymes under cold-hardening conditions. A change in the proportions of the different invertases appears to be one characteristic of cold hardening. The semimicromethod has been used to show that supplying extra sucrose to wheat seedlings will not duplicate this change.

Potato Diseases

Total and marketable yields produced from freshly cut seed pieces of potato treated with metiram were significantly greater than from untreated freshly cut seed in the Black soil zone. Treatment with captan also improved the marketable yields.

Bacterial ring rot, *Corynebacterium sepedonicum* (Spieck. & Kotth.) Skapt. & Burkh., persisted up to 5 days in soil at 20°C with the moisture content at field capacity. The organism remained viable for 15 days in soil held at 10°C at 50% field capacity.

PLANT SCIENCE

Cereals

Yield potential of spring \times winter wheat crosses. Significant levels of heterosis for yield in the F_1 of spring \times winter wheat crosses were reported in 1969. It has now been demonstrated that this yield advantage can be retained in advanced-generation spring wheat strains from spring \times winter crosses. Of four spring \times winter crosses, 95, 87, 64, and 46% of the strains, in contrast to

6% of those in a spring × spring cross, outyielded the highest spring wheat control.

These results show that the winter parent used in spring × winter wheat crosses can contribute important increases in yield to spring progenies. The results also support the concept that superior yielding progenies can be developed by bringing together genes from genetically diverse parents.

Wheat cytogenetics. Disomic whole chromosome substitution lines have been produced for all 21 chromosomes in the following series: Apex chromosomes into S-615, Rescue chromosomes into Cadet, and Cadet chromosomes into Rescue. Disomic substitution lines of chromosomes from *Agropyron elongatum* ($2n = 70$) for chromosomes 4D, 5D, and 6D of Rescue were increased in field plots. All three lines yielded more seed than similar plots of Rescue, 5D being most productive. Disomic addition lines of each of the three *Agropyron* chromosomes to Rescue have been extracted from the progenies of monosomic addition lines. These will be compared with the substitution lines to distinguish those characteristics of the substitution lines that are due to the *Agropyron* chromosomes from those due to the loss of the wheat chromosome.

Hector barley. A cultivar of two-rowed barley developed at Lethbridge was named Hector and licensed for sale in Canada. The Research Station at Regina supplied 536 hl (1,500 bu) of seed that was distributed to seed growers in Alberta and Saskatchewan through provincial seed distribution committees and private seed companies.

Hector has averaged 10% higher yield than Betzes on the Brown and Dark Brown soils of Alberta and Saskatchewan. It is more resistant to lodging and shattering than Betzes and less susceptible to scald. Malting and brewing trials in the laboratory and pilot plant scale tests have indicated that it is equal to Betzes in quality.

Corn

Exotic maize for silage. Four populations of maize from Mexico, evaluated for yield of total plant dry matter, produced over 20 t/ha. The plants had only 20% dry matter at harvest and did not form ears. A commercial tillering hybrid yielded 16.5 t/ha and had 27% dry matter, including some grain. Exotic maize varieties have the potential, in Canada, for high yields of energy per hectare, but

there are ensiling difficulties associated with their higher moisture at harvest. At present, it is not practical to use exotic maize to produce silage on farms.

Losses in a horizontal silo. Subsurface temperature differences up to 30°C were detected between the covered and uncovered ends of a horizontal silo 2 mo after filling. There was no observable spoilage under the cover. In a second silo in which the plastic cover was not well placed and was not sealed at the edges, about 10 cm of spoiled material was observed under the plastic. In that case, core samples taken through the complete depth of the silo showed no significant difference in dry matter losses between the covered and uncovered ends. These results suggest that a plastic cover will reduce losses effectively only if it is well placed and sealed.

Forage

Western wheatgrass. Over 450 ecotypes of western wheatgrass, *Agropyron smithii* Rydb., were collected throughout southern Alberta and Saskatchewan and transplanted into a uniform habitat at Lethbridge. High forage yields were generally associated with high seed yields, taller plants, and high visual ratings of productivity. The ecotypes differed in leaf color from green to blue, and varied in pubescence, awning, and yield. Such variability suggests that improvement through breeding is possible.

Sainfoin-grass mixtures on irrigated land. A test on irrigated land with sainfoin alone or in mixture with various grasses was completed in 1973 after 4 yr of simulated grazing, during which 13 harvests were taken. Average dry matter yield of sainfoin alone was 6,442 kg/ha annually; this exceeded the yield of any of the mixtures. The mixture of sainfoin and timothy had the highest dry matter yield, averaging 6,072 kg/ha annually. Sainfoin contributed 40–45% of the total forage produced by mixtures with timothy, creeping red fescue, or pubescent wheatgrass, but less than 20% of the mixtures with orchardgrass or brome grass. Total yields of dry matter and protein indicate that, for short-term (3–4 yr) irrigated pastures, sainfoin has the greatest potential if it is seeded alone rather than with a grass crop.

Tall wheatgrass – sorghum mixtures. In a row-spacing test of tall wheatgrass, forage sorghum was seeded annually between the

rows. Total dry matter yields were assessed on the basis of one harvest, taken in mid-August. In the first year of the test, though the interseeded sorghum reduced tall wheatgrass growth, it increased total yield. In subsequent years, the sorghum grew best between the most widely spaced rows (142 cm), but at all row spacings it depressed the growth of the tall wheatgrass and reduced total dry matter yield. It was concluded that, whereas combined cropping may be of some benefit in the first year, it is detrimental to yield in succeeding years. Tall wheatgrass yields increased to a maximum of 14.8 t/ha as row spacings decreased from 142 to 18 cm. This high yield suggests that tall wheatgrass has potential as an economical supply of forage for wintering cattle.

Horticulture

High-density planting of early cabbage. In a plant population study, yields of cabbage were 32–94 t/ha in 1973, compared with 55–224 t/ha in 1972. The differences were related to variations in head size from one season to the next. The smaller head sizes in 1973 could be attributed to very high temperatures for 3–4 wk before harvest. In both years, yields and gross returns increased progressively, but not proportionately, as densities increased. Increased costs of planting and harvesting of higher density crops tended to reduce net returns. This study suggests that net returns from the production of early cabbage are highest at plant densities of 35,000–40,000 plants/ha. Little benefit can be expected from densities beyond that range.

Sugar in sweet corn. In sweet corn grown on irrigated land, there was an inverse relationship between rate of fertilizer applied to the soil and kernel sugar content. Where nitrogen and phosphorus in a 9:2 ratio were applied at rates between 0 and 246 kg/ha, the total sugar content of the kernels varied from 2.1 to 3.4%. Though sugar content is an important factor in the quality of sweet corn, it was concluded that, at fertilizer rates up to 100 kg/ha, kernel quality would not be noticeably affected.

Miscellaneous pulse crops. The potential productivity of several exotic pulse crops has been evaluated in the search for new crops. Of the types examined, fababeans appear to

offer the greatest potential. Fababean cultivars grown on irrigated land produced 4.2–6.6 t/ha of seed with a protein content of 30%. Entire plants harvested for silage yielded 6.6 t/ha of dry matter with a protein content of 18%.

Several cultivars of lentils and of chick peas have produced as high as 2.2 t/ha of seed and appear to have some potential as a crop for domestic use and for export. Adzuki and mung bean cultivars tested to date have produced very low yields of seed at Lethbridge.

Weeds

Effects of rape straw on wild oats. In laboratory trials, natural dormancy of wild oat seeds was partially overcome when they were germinated between filter papers resting on measured quantities of ground rape straw. Of the seeds that would normally have remained dormant, 33–60% in various seed lots germinated. The decrease in natural dormancy was similar with rape straw at 250–2,000 kg/ha. Shoot growth of the seedlings appeared normal, but roots were short and distorted. Shoot-to-root ratios were 1:1.9 on filter paper only, and between 1:0.9 and 1:1.2 with the equivalent of 2,000 kg of rape straw/ha below the paper.

In pot tests, growth of wild oat plants was less in the presence of ground rape straw at rates equivalent to 1,000, 2,500, and 4,000 kg/ha. The green weight of wild oat plants, 28 days after seeding, was reduced more by rape straw incorporated into the soil than by straw deposited on the soil surface. Plant weights were further reduced when seeding was delayed until 8 or 16 days after the first watering of prepared pots. Again, little difference in effect on green weights was noted between the various rates of rape straw used.

Control of aquatic plants. Aquatic vegetation was controlled effectively, safely, and economically using a variety of herbicides alone or in mixture. The herbicides were selected on the basis of the type of vegetation to be controlled (emergent, submergent, free-floating, or floating-leaved), water chemistry, use of aquatic system (irrigation, livestock water, etc.), application techniques used, and length of time for which control was desired (temporary, seasonal, or multiseasonal).

Research is being directed toward selective control procedures for removing weed species and leaving desirable aquatic plants. For example, meadows of stonewort, or *Chara*, have been established using a mixture of diquat and paraquat injected underwater at concentrations of 1.5 ppm in the water to remove vascular plants. The advantage is that stonewort usually grows to a height of only 20 cm, and offers excellent cover for small aquatic animals such as freshwater shrimp and daphnia.

SOIL SCIENCE

Soil Fertility

N requirements of dryland grass. A large portion of the N fertilizer applied to dryland grass in southern Alberta was not used by the crop in 1973 because of the severe drought during the growing season. Most of the unused N remains in the root zone of the grass and will be available to succeeding crops. Results have shown that, under the variable moisture conditions of southern Alberta, maximum production of dryland grass can be obtained by establishing a nitrogen pool in the root zone of the grass by applying 130–180 kg N/ha the first year, and subsequently replacing the N taken up by the harvested crop each succeeding year.

High-protein wheat. Application of N fertilizer at about 400 kg/ha increased protein in grain of Neepawa, a hard red spring wheat, from 13.7% to 20.7% in 1972 and from 11.2% to 19.7% in 1973. The quality of the increased protein has not yet been fully assessed. Apparently, the high-protein wheat is low in at least one amino acid, L-lysine. High-protein wheat supplemented with L-lysine was successfully substituted for part of the soybean meal in a chick diet with a considerable saving in cost.

Response of potatoes to fertilizer and irrigation. Netted Gem potatoes yielded 53.3 t/ha (23.8 tons/ac) with adequate fertilizer (200 kg N, 100 kg P, and 100 kg K/ha) and timely irrigation (every 8 days during peak use). The nonfertilized plot yielded 40.6 t/ha. The average yield of potatoes grown under irrigation in southern Alberta is about 30 t/ha.

Irrigation, Drainage, and Salinity

Irrigation of rapeseed. Where rapeseed (cultivar Span) was irrigated regularly until the swathing stage, the average yield for 3 yr was 2,952 kg/ha. This was more than 2.5 times the yield without irrigation and almost 1.5 times the yield where irrigation was discontinued in early July. The responsiveness of rape to ample soil moisture until it reaches maturity appears to be related to the continuing enlargement of green photosynthesizing pod tissue. Thus, the water requirement of the crop remains high despite gradual reduction of leaf area after the first week of July.

Irrigation with sewage effluent. Irrigation of five forage species with municipal sewage effluent for 2 yr resulted in no evidence of adverse effects on the soil or groundwater. Application of effluent at 164 cm/yr produced 9,260 kg/ha of dry matter, which was 27% higher yield than when effluent was applied at 82 cm/yr. Much of this enhanced production has been attributed to N in the effluent because only at the low effluent level was a yield response obtained from added N fertilizer. Forage analysis indicated that most of the 56 kg/ha additional fertilizer N was taken up by the forages despite the 55–110 kg N/ha applied in the effluent. In fact, the forages were capable of removing up to 224 kg N/ha when adequate moisture was present.

All the P remained in the surface 15 cm of soil when P was applied at 160 kg/ha over 2 yr. High rates of effluent and fertilizer, applying 240 kg P/ha, resulted in P being leached only to the 15- to 30-cm depth. Groundwater samples show no evidence of accumulation of soluble salts, N, P, or coliform bacteria.

Efficiency of water use. Over a 3-yr period ending in 1973, Lemhi wheat yielded 5.8 t/ha, whereas Pitic 62 yielded 6.5 t/ha and used 2.3 cm less water per season. Pitic 62 had a significant production efficiency advantage: 105.0 kg of grain/cm of water used compared with 90.5 kg of Lemhi. Production efficiency differences were significant ($P = 0.01$) for years, varieties, and the years \times varieties interaction.

Daily evapotranspiration (ET) of Pitic 62 wheat grown in lysimeters was more closely correlated with evaporation (E) from a black porous disc atmometer than with individual

meteorological factors. Evaporation was as effective in predicting ET as was a combination of meteorological factors. The relationship of ET to E tended to depart from linearity at high evaporation rates and could be described best by a second-degree polynomial equation.

Water movement in soil profiles. Annual water movement under dryland conditions in the Lethbridge area was assessed by field moisture samplings and a Versatile Moisture Budget (VMB) model developed at the Plant Research Institute. Although the VMB model showed deep drainage below the root zone only in June 1969, calculations of unsaturated flow indicated that about 5 cm of water were lost from summerfallow in 2 of 5 yr. In the same period, under cultivated grasses and continuous wheat, the maximum available moisture in the top 122 cm of soil was 8 and 14 cm. These moisture contents are equivalent to suctions of 1–3 bars.

The results indicate that, during relatively moist seasons, summerfallowing can cause transfer of excess water to discharge areas and aggravate dryland salinity. Moisture uptake by growing plants in a continuous cropping system prevents accumulation and movement of water downward to below the root zone.

Reclamation of salinized soil by drainage. The use of subsurface drains 1.25 m deep and controlled leaching by irrigation effectively reclaimed a salinized loam soil at Vauxhall, Alta. Resalinization has not occurred after 2 yr of normal irrigation practices. Clay tile, perforated rigid or corrugated plastic drains all removed excess soil water satisfactorily. In general, the performance of plastic drains 65 mm in diam was equal to that of 105-mm clay tile, and the use of fiber glass or gravel envelopes increased the rate of discharge from plastic drains. Lined and unlined mole drains also continued to function well 5 yr after installation in a clay loam soil.

Chemistry and Physiology

Soil enzymes. Comparison of overgrazed and ungrazed grassland soils at two locations showed a more consistent and substantially greater rate of activity in the soil of dehydrogenase, phosphatase, invertase, and amylase in the overgrazed area than in the ungrazed.

Rhizosphere of spring wheat. Experiments were designed to determine the incidence of bacteria antagonistic in vitro to *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur in the rhizosphere of selected cultivars and their respective homoeologous substitution lines. The results showed that the association between root-rot resistance, governed by chromosome 5B, and the occurrence of antagonists in the rhizosphere and laimosphere is entirely coincidental. In contrast, the rhizosphere of conversely related varieties and substitution lines that are susceptible to root rot contained consistently more microorganisms that possessed the hydrolytic enzymes, cellulase, pectinase, and amylase.

Response of crops to soil-humus extracts. When added to nutrient solutions, humic substances extracted from a Dark Brown Chernozemic Ah, a Black Chernozemic Ah, and a Dark Gray Luvisol Ahe significantly increased the growth of tops of *Festuca scabrella* Torr. but not the roots and had no effect on the tops or roots of *Phaseolus vulgaris* L. Humic substances from the Dark Gray Luvisol enhanced ion uptake by *Festuca* more so than those from the Dark Brown and the Black soils; those from the Dark Brown soil had no effect. There were negligible differences in the response of either crop to humic substances obtained by three different methods of extraction.

Reactions affecting soil structure. Results have been obtained that clarify some of the reactions that are probably responsible for aggregate stability in some soils. Viscosities of suspensions of clays (bentonite, and peroxidized or nonperoxidized clay-organic complexes extracted from Black Chernozemic soil) and polysaccharides (extracts from Black Chernozemic soil or amylopectin from starch) were measured singly and in combination. The suspensions were prepared in water, in three buffer solutions, and in solutions of tetramethylammonium bromide.

The viscosity (η_{sp}/c) values indicate that polysaccharide and clay containing no organic matter combine to produce an ionic polymer. The buffer of low pH (4.5) or the quaternary salt precipitated the polymer; buffers at pH 6.65 and 8.0 suppressed the ionization of the polymer. It was also found that the nonperoxidized clay-organic complexes are ionic polymers and do not combine measurably with polysaccharides.

Wheat root characteristics and nutrient uptake. Injection of ^{32}P fertilizers to various depths in soil indicated that the growth of wheat roots was severely restricted by dry soil in lysimeters and in the field. N fertilizer did not affect root elongation during the very dry season of 1973.

Wheat roots in the surface 15 cm of soil were shown to be more efficient than deeper roots in uptake of both water and P. Maximum water uptake occurred during the period of maximum growth (about 60 days after planting), whereas most P uptake occurred before this.

Magnetic treatment of seed. The benefits of passing seed through a magnetic field before planting have been further demonstrated. Using two commercial magnetic seed treaters, average yields were increased 7.0–16.2% in three of four cereals. Compared to untreated seed, Sundance winter wheat survived the winter slightly better and yielded about 7.0% more; yields of Neepawa and Glenlea spring wheat were increased by 11.8 and 16.2%; and Galt barley produced slightly more heads per plant and yielded 10.3–13.0% more. There was no effect on the growth or yield of Sioux oats. Two commercial corn hybrids grown from magnetically treated seed emerged 1–3 days earlier than those grown from untreated seed.

VETERINARY-MEDICAL ENTOMOLOGY

Biting Flies

Mosquitoes. Further progress was made in the culture of the fungus *Coelomomyces psorophorae* Couch in laboratory colonies of *Culiseta inornata* (Williston). Supplies of sporangia can now be maintained for experimental work on biological control of mosquitoes without collections from field sources of the pathogen. Environmental conditions necessary for germination of the sporangia have been determined. Evidence from field studies in southern Alberta indicates that release of the pathogen to control *Aedes vexans* (Meigen) as well as *C. inornata* may be possible. Up to 0.67% of *A. vexans* and 83% of *C. inornata* were infected with fungus when found as coinhabitant species in pools of water.

Black flies. Plastic cones were improved as an artificial substrate in a sampling technique

for larvae in large rivers. The method was used to locate breeding sites in the Athabasca River. Consistently greater numbers of *Simulium arcticum* Malloch, estimated at 16-km (10-mi) intervals, were found in the river 88–129 km (55–80 miles) downstream from the town of Athabasca than within 48 km (30 miles) upstream. The number of adults captured in flight above the surface of the water after emergence agreed with larval samples at marked sampling sites. The average density of adults over the river, 34 flies/km, was about 15% of that recorded in 1971 and 1972. The lower populations in 1973 caused no visible distress in cattle in the immediate vicinity of sampling sites along the river.

The sharp decrease in the adult population of *S. arcticum* in the Athabasca area in 1973 is the second decrease since the studies were organized during the severe outbreaks in 1967 and 1968. The previous marked decline in numbers was recorded in 1969.

Studies on adult infestations were extended to cattle-producing locations throughout Athabasca County and the adjacent areas. Results indicated that cattle are exposed to attack from late May to early October. Pest species in order of abundance are *S. arcticum*, *S. venustum* Say, *S. vittatum* Zetterstedt, and *S. decorum* Walker. *S. venustum* was a problem in late spring and *S. arcticum* throughout the summer. In contrast with reduced infestations of *S. arcticum* in Athabasca County, this species caused a problem for cattle producers near Wandering River.

Interruption of water flow in Flat Creek produced mortality rates of 30–70% in larval populations. Variations in mortality depended on weather and it was shown that larvae were more successful in escaping lethal desiccation during water stoppage on cool moist days than on warm dry days.

Environmental management in chemical control. Studies were initiated to monitor nontarget organisms in experimental chemical control of black flies in river systems. Good progress has been made in developing sampling methods and in establishing baselines for indicator species. Nontarget sampling systems have embraced eight orders of invertebrates containing 27 families and 35 genera as well as several species of fish.

Warble Flies

Sterilization. Extended experiments to determine effects of γ -irradiation of puparia on sexual sterility of warble flies showed that under severe field conditions few treated puparia emerged as adults. Adult emergence from treated puparia reared in the laboratory was about 40–60% higher than from puparia of the field population. Flies reared in the laboratory and released at mating sites in the field were competitive with indigenous ones.

Host-Parasite Relations

Resistance of cattle to grubs. Claims in the literature that systemic pesticidal control of grubs increased resistance of treated cattle to subsequent infestations may be unfounded. In controlled experiments, survival of larvae in untreated animals was reduced from 65% in the first inoculation to 19% in the second. Larval survival was 50% in animals from which invading grubs had previously been eliminated by treatment with trichlorfon. This level was not significantly different from that found after the first inoculation of untreated animals. In view of important practical and immunological implications, this host-parasite relation is being explored further in a series of successive inoculations with and without chemotherapy.

Serology. A crude antigen of first-instar *Hypoderma lineatum* (de Villers) has been fractionated by gel chromatography and assayed immunoelectrophoretically against rabbit antisera. One fraction has 10 times the N content of the next largest. The high-N fraction proved to be a 'poor' antigen in that it does not stimulate antibody formation readily in rabbits. These studies will be extended to determine if this fraction is a poor antigen in eliciting antibody response in cattle. Such a finding in conjunction with the detection of the homologous antibody in resistant cattle would establish our theory that immune antigens are poor stimulators of antibody.

Crude extracts from first-instar grubs contain at least three proteolytic enzymes. Two of these reduce collagen.

Control of Synanthropic Flies in Cattle Feedlots

Releases of three imported parasites, *Tachinaephagus zealandicus* Ashm., *Spalangia endius* Walker, and *Muscidifurax raptor* G. & S., in feedlots to control muscoid nuisance flies were integrated with scheduled removal of manure packs and secondary treatment of adult flies with dichlorvos at bait stations. This program reduced numbers of flies by up to 90%. The parasite component was responsible for about 60% of fly control at peak infestations immediately after release but only accounted for an average reduction of 25% during most of the fly period. Further experiments are designed to increase parasitism by adjusting the numbers released and the time of release.

Chemical Control

Toxicology. A dermal dose of crufomate at 100 mg/kg produced both short- and long-term effects in 7-day-old mice. Of the treated mice, 16% died within 4 days and the conception rate in the first and second pregnancies of the surviving treated females was reduced by 30% and 25%.

Parasite control. A pour-on application of trichlorfon at 25 mg/kg was 100% effective for systemic control of grubs in yearling heifers. The treated heifers outgained untreated animals (0.95 vs. 0.81 kg/head per day, $P < 0.01$) during March when most of the grubs were lodged in their backs. Differences in weight disappeared by the end of May after grubs emerged from the untreated animals.

Surveillance of the Alberta Warble Extermination Program was maintained in Wetaskiwin County, where it was started. Farms importing cattle were found to be at the centers of reinfestations. Indigenous cattle in other parts of the county appear to be free of grubs. A second warble extermination program was started in the Agricultural Extension Districts of Eastend, Maple Creek, Leader, and Swift Current, in southwestern Saskatchewan. The baseline infestation before treatments was about 20 grubs/head in yearling heifers.

PUBLICATIONS

Research

- Bailey, C. B. 1973. Formation of siliceous urinary calculi in calves given supplements containing large amounts of sodium chloride. *Can. J. Anim. Sci.* 53:55-60.
- Basu, F. K., Crete, R., Donaldson, A. G., Gourley, C. O., Haas, J. H., Harper, F. R., Lawrence, C. H., Seaman, W. L., Toms, H. N. W., Wong, S. I., and Zimmer, R. C. 1973. Prevalence and severity of diseases of processing peas in Canada. *Can. Plant Dis. Surv.* 53:49-57.
- Bole, J. B. 1973. Influence of root hairs in supplying soil phosphorus to wheat. *Can. J. Soil Sci.* 53:169-175.
- Boulard, C., and Weintraub, J. 1973. Immunological responses of rabbits artificially infested with the cattle grubs *Hypoderma bovis* (L.) and *H. lineatum* (de Vill.) (Diptera: Oestridae). *Int. J. Parasitol.* 3:379-386.
- Bowden, D. M. 1973. Effects of postfeeding interval on blood constituents related to energy metabolism in nonpregnant Angus and Hereford heifers. *Can. J. Anim. Sci.* 53:641-646.
- Bowden, D. M., Freyman, S., and McLaughlin, N. B. 1973. Comparison of nutritive value of silage from a tillering and a nontillering hybrid corn. *Can. J. Plant Sci.* 53:817-819.
- Charnetski, W. A., and Lichtenstein, E. P. 1973. Penetration and translocation of ^{14}C -lindane in pea plants. *J. Econ. Entomol.* 66:344-349.
- Charnetski, W. A., Lichtenstein, E. P., and Evert, R. F. 1973. Effects of lindane on cell structure of pea roots. *Can. J. Bot.* 51:2111-2117.
- Cheng, K.-J. 1973. Spheroplast formation by an anaerobic gram-negative bacterium *Bacteroides ruminicola*. *Can. J. Microbiol.* 19:667-669.
- Cheng, K.-J., and Costerton, J. W. 1973. Localization of alkaline phosphatase in three gram-negative rumen bacteria. *J. Bacteriol.* 116:424-440.
- Cheng, K.-J., Costerton, J. W., Singh, A. P., and Ingram, J. M. 1973. Susceptibility of whole cells and spheroplasts of *Pseudomonas aeruginosa* to actinomycin D. *Antimicrob. Agents Chemother.* 3:399-406.
- Cheng, K.-J., and Hironaka, R. 1973. Influence of feed particle size on pH, carbohydrate content, and viscosity of rumen fluid. *Can. J. Anim. Sci.* 53:417-422.
- Cheng, K.-J., Hironaka, R., Roberts, D. W. A., and Costerton, J. W. 1973. Cytoplasmic glycogen inclusions in cells of anaerobic gram-negative rumen bacteria. *Can. J. Microbiol.* 19:1501-1506.
- Dormaar, J. F. 1973. A diagnostic technique to differentiate between buried gleysolic and chernozemic B horizons. *Boreas* (Oslo) 2:13-16.
- Dormaar, J. F. 1973. Extraction of organic matter from chernozemic Ah horizons. *Sci. Sol* 1973(2):71-79.
- Dubetz, S., and Bole, J. B. 1973. Effects of moisture stress at early heading and of nitrogen fertilizer on three spring wheat cultivars. *Can. J. Plant Sci.* 53:1-5.
- Dubetz, S., and Krogman, K. K. 1973. Comparison of methods of scheduling irrigations of potatoes. *Am. Potato J.* 50:408-414.
- Freyman, S., Charnetski, W. A., and Crookston, R. K. 1973. Role of leaves in the formation of seed in rape. *Can. J. Plant Sci.* 53:693-694.
- Freyman, S., Kaldy, M. S., Bowden, D. M., and Wilson, D. B. 1973. Nutritive potential of multitillering corn compared with nontillering corn for silage. *Can. J. Plant Sci.* 53:129-130.
- Gardiner, E. E. 1973. A comparison of corn, Glenlea, Pitic 62, and Neepawa wheats in broiler diets. *Can. J. Anim. Sci.* 53:547-550.
- Gardiner, E. E. 1973. Inorganic phosphorus, organic phosphorus, and inorganic calcium in blood plasma from two breeds of chickens fed various levels of dietary calcium and phosphorus. *Can. J. Anim. Sci.* 53:551-556.
- Gardiner, E. E. 1973. Comparison of linseed oil with animal tallow as a source of energy in broiler diets. *Can. J. Anim. Sci.* 53:557-560.
- Gardiner, E. E. 1973. Effects of egg weight on posthatching growth rate of broiler chicks. *Can. J. Anim. Sci.* 53:665-668.
- Hanna, M. R. 1973. Registration of Kane alfalfa (Reg. No. 58). *Crop Sci.* 13:130.
- Harper, A. M. 1973. English grain aphid: Effect on yield of wheat in Alberta. *J. Econ. Entomol.* 66:1326.
- Harper, F. R. 1973. A key to standardize the description of growth stages in turnip rape, *Brassica campestris*. *Can. Plant Dis. Surv.* 53:93-95.
- Haufe, W. O. 1973. Interaction of pesticidal toxicity, parasites, and reversible anticholinesterase activity as stresses on growth rate in cattle infested with horn flies *Haematobia irritans* L. *Toxicol. Appl. Pharmacol.* 25:130-144.
- Hawn, E. J. 1973. Plant-parasitic nematodes in irrigated soils of Alberta. *Can. Plant Dis. Surv.* 53:29-30.

- Hironaka, R., and Kozub, G. C. 1973. Compensatory growth of beef cattle restricted at two levels for two periods. *Can. J. Anim. Sci.* 53:709-715.
- Hironaka, R., Miltimore, J. E., McArthur, J. M., McGregor, D. R., and Smith, E. S. 1973. Influence of particle size of concentrate on rumen conditions associated with feedlot bloat. *Can. J. Anim. Sci.* 53:75-80.
- Hobbs, E. H. 1973. Crop cooling with sprinklers. *Can. Agric. Eng.* 15:6-8.
- Ingram, J. M., Cheng, K.-J., and Costerton, J. W. 1973. Alkaline phosphatase of *Pseudomonas aeruginosa*: The mechanism of secretion and release of the enzyme from whole cells. *Can. J. Microbiol.* 19:1407-1415.
- Kaldy, M. S., and Freyman, S. 1973. Relationship between soil fertilization and total sugar content in sweet corn. *Can. J. Plant Sci.* 53:863-864.
- Kasting, R., and McGinnis, A. J. 1973. Construction and operation of a 'clean room' to avoid infectious disease when rearing the pale western cutworm. *Lab. Pract.* 22:368-369.
- Kemp, G. A. 1973. Initiation and development of flowers in beans under suboptimal temperature conditions. *Can. J. Plant Sci.* 53:623-627.
- Khan, M. A. 1973. Toxicity of crufomate to calves exposed to warble flies (*Hypoderma* spp.). *Res. Vet. Sci.* 15:180-186.
- Khan, M. A. 1973. Toxicity of systemic insecticides: Toxicological considerations in using organophosphorus insecticides. *Vet. Rec.* 92:411-419.
- Khan, M. A. 1973. Toxicity of systemic insecticides: Efficacy of dermal and parenteral applications of crufomate for systemic control of *Hypoderma* spp. in cattle. *Vet. Rec.* 93:528-532.
- Krogman, K. K., and Hobbs, E. H. 1973. Evapotranspiration by beans during low-volume sprinkling. *Int. J. Biometeorol.* 17:301-306.
- Krogman, K. K., and Torfason, W. E. 1973. Frequent low-volume sprinkler irrigation of potatoes. *Am. Potato J.* 50:133-138.
- Lilly, C. E. 1973. Wireworms: Efficacy of various insecticides for protection of potatoes in southern Alberta. *J. Econ. Entomol.* 66:1205-1207.
- Lindsay, S. S., Wheeler, B., Sanderson, K. E., Costerton, J. W., and Cheng, K.-J. 1973. The release of alkaline phosphatase and of lipopolysaccharide during the growth of rough and smooth strains of *Salmonella typhimurium*. *Can. J. Microbiol.* 19:335-343.
- Lutwick, L. E., and Dormaar, J. F. 1973. Fe status of Brunisolic and related soil profiles. *Can. J. Soil Sci.* 53:185-197.
- Moskaluk, E. R., and Hawn, E. J. 1973. A mechanical sieving apparatus for nematode extraction. *J. Nematol.* 5:72.
- Neal, J. L., Jr. 1973. Influence of selected grasses and forbs on soil phosphatase activity. *Can. J. Soil Sci.* 53:119-121.
- Neal, J. L., Jr., Larson, R. I., and Atkinson, T. G. 1973. Changes in rhizosphere populations of selected physiological groups of bacteria related to substitution of specific pairs of chromosomes in spring wheat. *Plant Soil* 39:209-212.
- Nelson, G. A., and Harper, F. R. 1973. Some factors affecting ring rot development in root-inoculated potato plants originating from stem cuttings. *Am. Potato J.* 50:365-370.
- Roberts, D. W. A. 1973. A survey of the multiple forms of invertase in the leaves of winter wheat, *Triticum aestivum* L. emend Thell. ssp. *vulgare*. *Biochim. Biophys. Acta* 321:220-227.
- Sommerfeldt, T. G., Pittman, U. J., and Milne, R. A. 1973. Effect of feedlot manure on soil and water quality. *J. Environ. Qual.* 2:423-427.
- Sommerfeldt, T. G., and Smith, A. D. 1973. Movement of nitrate nitrogen in some grassland soils of southern Alberta. *J. Environ. Qual.* 2:112-115.
- Struble, D. L. 1973. Conditioning of polyalkyl glycol liquid phases for flame photometric gas chromatographic analysis of Dursban and its oxygen analog. *J. Assoc. Off. Anal. Chem.* 56:49-52.
- Struble, D. L., and McDonald, S. 1973. Residue analysis of chlorpyrifos and its oxygen analogue in field-treated wheat plants. *J. Econ. Entomol.* 66:769-772.
- Struble, D. L., and McDonald, S. 1973. Residue analysis of leptophos, its oxygen analog, and its phenol in field-treated wheat plants. *J. Econ. Entomol.* 66:1321-1325.
- Trpis, M., Haufe, W. O., and Shemanchuk, J. A. 1973. Embryonic development of *Aedes (O.) sticticus* (Diptera: Culicidae) in relation to different constant temperatures. *Can. Entomol.* 105:43-50.
- Vesely, J. A. 1973. Growth rates, carcass grades, and fat composition in ram lambs, wether lambs, and induced cryptorchids. *Can. J. Anim. Sci.* 53:187-192.
- Vesely, J. A. 1973. Skinning time for ram and wether lambs and its implication in pricing and marketing entire males. *Can. J. Anim. Sci.* 53:195-196.

- Vesely, J. A. 1973. Fatty acids and steroids affecting flavor and aroma of meat from ram, cryptorchid, and wether lambs. *Can. J. Anim. Sci.* 53:673-678.
- Vesely, J. A., and Gardiner, E. E. 1973. Urinary excretion of 11-deoxy 17-ketosteroids and their correlations with other unknown steroid compounds in ram, cryptorchid, and wether lambs. *Can. J. Anim. Sci.* 53:679-687.
- Wells, S. A. 1973. Hector barley. *Can. J. Plant Sci.* 53:497-498.
- Miscellaneous**
- Allan, J. R., and Smoliak, S. 1973. Maintaining water quality through aquatic vegetation control. Pages 140-151 in *Water-animal relations symposium*. Univ. Idaho, Twin Falls, Idaho, June 26-28, 1973.
- Bowden, D. M. 1973. Efficiency of feed utilization for calf production. *Canadex* 420.60.
- Dubetz, S. 1973. Research helps potato industry grow. *Can. Agric.* 18(4):18-19.
- Forbes, L. M., Wroe, R. A., Smoliak, S., Johnston, A., and Maduram, G. H. 1973. Range, its nature and use. *Alta. Dep. Lands Forests, Publ. L2*. 4th ed.
- Freyman, S., MacDonald, M. D., and Bole, J. B. 1973. Corn in Alberta. *Can. Agric.* 18(2):8-10.
- Freyman, S., and Sexsmith, J. J. 1973. Alberta Corn Committee list of hybrids recommended for 1973—heat unit map and guide to corn production in Alberta. *Alta. Corn Comm., Lethbridge, Alta.*
- Grant, M. N. 1973. Sundance—a hard red winter wheat. *Can. Agric.* 18(3):10.
- Harper, A. M. 1973. Aphids—their importance and control. *Can. Agric.* 18(4):34-36.
- Harper, A. M. 1973. Insects. Pages 92-96 in G. S. Reycraft, ed. *The 1973 prairie garden*. Winnipeg Hort. Soc., Winnipeg, Man.
- Harper, F. R. 1973. White rust on rape. *Canadex* 149.630.
- Haufe, W. O. 1973. Systems evaluation: Its role in assessing and monitoring biting fly research and in developing control procedures. Pages 39-48 in A. Hudson, ed. *Symposium on biting fly control and environmental quality*, proceedings of a symposium held at the University of Alberta, Edmonton, May 16-18, 1972. *Def. Res. Board, Ottawa.*
- Hironaka, R., and Cheng, K.-J. 1973. Feedlot bloat—advances in knowledge and prevention. *Can. Agric.* 18(4):12-15.
- Hironaka, R., and Cheng, K.-J. 1973. Less bloat with coarse feed. *Canadex* 401.55.
- Hobbs, G. A. 1973. Alfalfa leafcutter bees for pollinating alfalfa in Western Canada. *Can. Dep. Agric. Publ.* 1495. 30 pp.
- Hobbs, G. A. 1973. Alfalfa leafcutter bees. *Canadex* 121.615.
- Horricks, J. S., Kasting, R., and Pittman, U. J. 1973. Rapeseed residues slow plant growth. *The Manit. Co-op.* 30(33):13a.
- Johnston, A., Smoliak, S., Hanna, M. R., and Hironaka, R. 1973. Cicer milkvetch. *Mimeogr. Publ., Res. Stn., Can. Dep. Agric., Lethbridge, Alta.* 17 pp.
- Khan, M. A. 1973. Cattle grub control. *Canadex* 401.651.
- Khan, M. A. 1973. Control of cattle grubs. *Can. Dep. Agric. Publ.* 1309 (revised). 15 pp.
- Khan, M. A. 1973. Reproduction in female mice treated with crufomate at the age of seven days. Pages 513-520 in W. B. Deichmann, ed. *Pesticides and the environment: a continuing controversy*. Vol. 2. 8th Inter-Am. Conf. on Toxicol. and Occup. Med., Univ. of Miami, Miami, Florida.
- Larson, R. I., and Atkinson, T. G. 1973. Wheat-*Agropyron* chromosome substitution lines as sources of resistance to wheat streak mosaic virus and its vector, *Aceria tulipae*. Pages 173-177 in *Proc. 4th Int. Wheat Genet. Symp.* Missouri Agr. Exp. Stn., Columbia, Mo.
- Lebeau, J. B. 1973. Diseases and pests of turfgrass in the Prairie Provinces. *Can. Dep. Agric. Publ.* 1247 (revised). 9 pp.
- Lindwall, C. W. 1973. Zero tillage increases yields. *Canadex* 516.
- Russell, K. D., and Sonntag, B. H. 1973. Alfalfa seed production. *Canadex* 121.15.
- Russell, K. D., and Sonntag, B. H. 1973. Alfalfa seed production. *Can. Farm Econ.* 8(1):8-13.
- Sexsmith, J. J., and Trimmer, R. M. 1973. Chemical weed control in specialty crops for Alberta, 1973. *Alta. Dep. Agric. Publ.* 641-250 (revised). 10 pp.
- Slen, S. B. 1973. Blonde d'Aquitaine. *Canadex* 401.32.
- Slen, S. B. 1973. Pinzgauer cattle. *Canadex* 420.32.
- Smith, A. D. 1973. Grass tetany and N fertilization of two grass species in southern Alberta. *Canadex* 540.
- Smith, A. D. 1973. Fertilizers not polluters on dryland grass. *Canadex* 540.
- Smoliak, S., and Johnston, A. 1973. A new forage crop—cicer milkvetch. *Can. Agric.* 18(2):30-31.

- Smoliak, S., and Johnston, A. 1973. Genetic variability in *Agropyron smithii* Rydb. Pages 30-33 in Proc. 22nd Western Grass Breeders Work Planning Conf., Swift Current, Sask.
- Smoliak, S., and Slen, S. B. 1973. Effect of grazing intensity on wool production. Canadex 430.10.
- Sommerfeldt, T. G. 1973. Dryland salinity. Canadex 535.
- Sommerfeldt, T. G. 1973. Nitrate-nitrogen pollution of surface and ground waters. Can. Agric. 18(3):23-25.
- Vesely, J. A. 1973. Comparative market value of ram lambs and wethers. Canadex 430.844.
- Vesely, J. A. 1973. Increased production of lamb by crossbreeding. Can. Agric. 18(2):26-27.
- Wells, S. A. 1973. Panelist in discussion on "Outlook for Canadian High Energy Grain." Pages 43-44 in Proc. High Energy Grains and Oilseeds Conf., Jan. 1973.

Research Station Agassiz, British Columbia

PROFESSIONAL STAFF

J. E. MILTIMORE, B.S.A., M.Sc., Ph.D.	Director
R. J. FORREST, B.S.A., M.S.A., Ph.D.	Animal physiology; meat studies
J. A. FREEMAN, B.S.A., M.S.A., Ph.D.	Physiology of small fruits; herbicides
A. T. HILL, ¹ B.S.A., M.S.A., Ph.D.	Poultry management
J. R. HUNT, B.S.A., Ph.D.	Poultry physiology
M. K. JOHN, ² B.Sc. (Agr.), M.S., Ph.D.	Soil chemistry; soil fertility
E. F. MAAS, B.S.A., M.S.A.	Plant nutrition; nonsoil media
A. R. MAURER, B.S.A., M.Sc.	Physiology of vegetable crops
D. K. TAYLOR, B.S.A., M.Sc., Ph.D.	Turfgrass management

Departures

H. A. DAUBENY, B.S.A., M.S.A., Ph.D. Transferred to Research Station, Vancouver, B.C., July 1973	Plant breeding, small fruits
W. E. P. DAVIS, B.S.A., M.S.A. Retired July 1973	Forage management
D. E. WALDERN, B.S.A., M.Sc., Ph.D. Transferred to Research Station, Kamloops, B.C., as Director, July 1973	Animal nutrition

¹On transfer of work to the British Agricultural Council, Edinburgh, Scotland, September 1972 to September 1973.

²On transfer of work at the Soils Departments of the University of Western Australia, Perth, Australia, and Lincoln College, Canterbury, New Zealand, August 1972 to August 1973.

INTRODUCTION

This report briefly summarizes some of the research completed in 1973 at the Research Station, Agassiz. Further details are available in the listed published papers and reports and in the Research Review, which is issued quarterly by the Station. Correspondence should be addressed: Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0.

J. E. Miltimore
Director

ANIMAL SCIENCE

Ruminants

Charolais × *Holstein F-1* crossbreds. Compared with purebred Holstein-Friesian steers, first-generation Charolais × Holstein crossbreds gained faster, used feed more efficiently, had larger rib eyes, and produced more lean meat when slaughtered at 500 kg (1,100 lb). The Holstein-Friesian steers had more depot fat and subcutaneous fat than the crossbreds and consequently yielded 2% less wholesale carcass. The two groups did not differ significantly in yield of high- or low-priced wholesale cuts, but on the basis of rib fat depth and carcass weight the Holstein-Friesians would have been graded A-2 and the crossbreds A-1.

Births of crossbred offspring were more difficult. Of eight virgin heifers bred to Charolais sires, two had normal deliveries, two had stillbirths, and four experienced extreme difficulties; only one of the last four heifers recovered after delivery. Conformation rather than birth weight appeared to be the major cause of calving difficulties, because the crossbreds had shorter, shallower, and wider bodies than the purebreds.

Six of the female crossbred offspring were assessed for milk-production potential. Their production for an 180-day lactation averaged 2,103 kg, only 63% of their dams' production during a comparable period.

Fertility in dairy cattle. A cooperative study with commercial dairymen, the University of British Columbia, and the British Columbia Department of Agriculture has revealed that the main cause of low conception rates among dairy cattle is inadequate mineral nutrition. In the diets of several problem herds the levels of many elements, including Ca, P, Cu, and Se, were well below the quantities recommended for dairy cattle.

There was a suggestion that diets composed predominantly of silage were associated with low fertility. The average concentrations of Cu and Se in corn silage were approximately 66% and 50% of those found in grass hay.

Poultry

Broilers and roasters reared under intermittent light. Both broilers and 14-wk roasters performed better and had fewer leg problems when reared under a regime of 1 h of light followed by 3 h of darkness than when under continuous light. An intermittent system of 1 h of light and 3 h of darkness during the night, with 13 h of continuous light during the day, gave poorer results than continuous light.

Cage density and population size. Laying hens of two commercial strains housed in groups of 3, 6, and 12 birds outperformed those in colonies of 18, 24, and 30 birds, irrespective of density. None equaled the controls, which consisted of 1 bird per cage with a floor space of 619 cm² (96 sq in.). Floor spaces of 387 and 465 cm² (60 and 72 sq in.) per bird gave better results than spaces of 310 cm² (48 sq in.) per bird. Cannibalism was the main cause of death.

Foot sores among caged laying hens. Removal of the last phalanx from each toe of day-old chicks resulted in an increase in the incidence of foot sores when they were caged as layers on 2.5 × 5-cm (1 × 2-in.), 14-gauge, welded wire. Hens kept at a floor space of 310 cm² (48 sq in.) per bird tended to suffer the most. Removal of terminal phalanges is not recommended even though it reduces back scratching and resultant cannibalism in the laying house.

CROP SCIENCE

Ornamentals

Turfgrass mixtures for lawns. Botanical studies of lawn mixtures of red fescue cv. Boreal and Pennlawn, Kentucky bluegrass cv. Merion and Park, and bentgrass cv. Highland seeded in single and multiple combinations have demonstrated the aggressiveness of Highland bentgrass. Under conditions of good moisture, fertility, and freedom from traffic, bentgrass dominated each mixture in which it was a component, especially at the lower cutting height (1.9 cm). Differences among plant populations seeded at three ratios were negligible at the end of a 3-yr period.

Differences among cultivars were as great as those among species in mixtures of red fescue and Kentucky bluegrass. Pennlawn and Merion were much more competitive than Boreal and Park. Susceptibility to *Drechslera poae* (Baudys) Shoem. was responsible for the poor performance of Park. When red fescue and Kentucky bluegrass cultivars of equal competitive ability were combined in seeding ratios of 3:1 and 1:1, a good balance of each species was obtained at the end of the 3-yr period.

Small Fruits

Activated charcoal with preplant herbicides in strawberries. Simazine, Kerb (Rohm & Haas Ltd.), and a mixture of simazine and diphenamid, although useful treatments for control of weeds in strawberries, cause injury to the crop when applied before or immediately after planting. This injury was reduced or eliminated when activated charcoal was used as a root dip at planting.

Strawberry breeding. Three selections have been chosen for more extensive testing as processing berries because, like Totem, they outyield Northwest and they are more winter-hardy, and because the fruit is equal in quality. Three other selections have been chosen for the fresh market. One of these ripens early and another late, while the third selection produces large fruits throughout the season.

Tomato ringspot virus on raspberry cultivars. In a study undertaken in cooperation with the Research Station at Vancouver, 10 cultivars were successfully graft-inoculated with tomato ringspot virus (Tom RSV) in

1970. The results to date show the effects of Tom RSV on plant and fruit development of raspberries vary considerably, depending on the cultivar; Lloyd George was the most severely injured and Glen Clova and Meeker were the least. After 5 yr in the field, a clone of the red raspberry cultivar Newburgh infected with Tom RSV showed normal fruit development. Examination of the planting in the 6th yr revealed two plant types, those apparently normal and those showing symptoms of decline.

Critical levels of nutrients in raspberry. Leaf levels of B, Ca, S, and Mo were found to differ markedly in 14 red raspberry genotypes, and significant but smaller differences occurred in levels of N, P, K, Mg, Na, Zn, and Fe. Levels of Mn, Al, and Cu did not vary significantly according to genotype. In the cultivar Willamette, all elemental concentrations except those of Mg and Mo were influenced significantly by sampling date. Age of the plant had little effect on chemical composition of leaves.

Red raspberry breeding. Seven of nine advanced selections were immune to *Amphorophora agathonica* Hottes, the aphid vector of red raspberry mosaic virus. Two selections outyielded Willamette but not Haida, the cultivar released in 1973. Five selections produced canes with greater survival than Willamette.

Matsqui, Cuthbert, and Ottawa showed low susceptibility to the organisms *Botrytis cinerea* Pers. and *Rhizopus* spp. [probably *R. stolonifer* (Ehr. ex Fr.) Vuill.], which cause fruit rot. Malling Exploit, Malling Promise, Puyallup, and St. Walfried were highly susceptible to both organisms. Malling Jewel showed low susceptibility to *B. cinerea* and high susceptibility to *Rhizopus* spp., whereas Sumner showed the reverse. Cuthbert appeared to be a source of genes for low susceptibility to both organisms.

Vegetables

Herbicide treatments for lettuce seedbeds. The herbicide Roundup (Monsanto Canada Ltd.) at rates of 0.55 and 1.1 kg/ha (0.5 and 1 lb/ac) and a mixture of sulfallate, chlorpropham, and paraquat at 2.2, 2.2, and 0.28 kg/ha (2, 2, and 0.25 lb/ac) respectively, sprayed when weeds were small but before crop emergence (stale seedbed), gave good initial control of broad-leaved weeds and grass when used as treatments for

lettuce. The mixture had a good residual effect but Roundup did not.

Textural studies. Textural studies of snap beans and sweet corn, harvested to provide a range from immature to overmature, showed that rheological values obtained with the Brookfield and Haake Rotovisko viscometers were useful indicators of both maturity and quality. With sweet corn, the Rotovisko flow behavior index was negatively correlated with percentage of moisture and positively correlated with refractive index and specific gravity. With beans, peak force readings of the Kramer shear press and the Ottawa Texture Measuring System were either negatively or positively significantly correlated with all textural quality and viscometric parameters obtained with the Brookfield and the Adams-type consistometer.

Growth regulators on Brussels sprouts. Experiments conducted over 4 yr have shown that Brussels sprouts cultivars respond differently to application of the growth regulator Alar (UniRoyal Chemicals). Sweet Coastal, a late-maturing cultivar, showed little response whereas with Jade Cross, an early-maturing cultivar, application of Alar increased the compactness of sprouts and made their removal from the stem difficult. With Jade Cross and with Hedda, a mid-season cultivar, time of application had a greater effect than rate of application on reducing plant height.

The earlier treatment (6 wk after transplanting) had a greater dwarfing effect than the late application (10 wk after transplanting). With the cultivar Hedda, Alar at 8,000 ppm applied 8 wk after transplanting produced the greatest marketable yield. However, application of 8,000 ppm either 6 or 10 wk after transplanting also produced yields significantly better than the controls.

Nonsoil Media

Rooting geranium cuttings. Media with properties of high moisture retention and moderate porosity promoted rapid rooting of geranium cuttings. The percentage of plants

that produced roots in a 21-day test period was only 33% in a mixture containing equal parts of sand and soil, compared with 78% in a mixture containing equal parts of sand, soil, and peat.

Peat added to a fine spruce sawdust as 25% of the mixture increased rooting from 67% to 89%, whereas added to coarse fir sawdust the peat increased rooting from 33% to 89%. There was a 10% loss of cuttings because of stem rots in a sand-soil mixture, but no losses occurred in media containing either peat or sawdust.

Contamination of a sawdust growing medium by seawater. Sawdust obtained from logs contaminated with salt from seawater has been detrimental when used as a growing medium for tomatoes. The cultivar Vendor grown in salt-treated sawdust showed a moderate yield increase when shaded to reduce transpiration, but Vantage showed more tolerance for salt and did not benefit from the shade treatment.

SOIL SCIENCE

Levels of available K in samples of Monroe silt loam from a field experiment in the lower Fraser Valley were significantly greater in the spring than in the previous summer. Samples collected in October contained available K at a level of 214 kg/ha, whereas samples collected the following May contained 296 kg/ha. Increased availability of K in spring results from the transformation and release of mineral and fixed K to the available form during the winter. These findings indicate that recommendations for application of K fertilizer should take the time of sampling into consideration.

A new procedure was developed for the extraction of boron by hot water. The method is suitable for handling a large number of samples and allows for boron analyses in routine soil testing. The reproducibility of the proposed method was found to be superior to that of existing methods.

PUBLICATIONS

Research

- Barritt, B. H., Daubeney, H. A., Lawrence, F. J., Norton, R. A., Martin, I. W., and Crandall, P. C. 1973. Performance of strawberry cultivars and advanced selections in the Pacific Northwest. *Fruit Var. J.* 27:63-68.
- Buckland, R. B., Hill, A. T., and Bernon, D. E. 1973. Effects of four lighting regimes on the performance of broilers and roasters. *Can. J. Anim. Sci.* 53:21-24.
- Daubeney, H. A. 1973. Haida red raspberry. *Can. J. Plant Sci.* 53:345-346.
- Daubeney, H. A., and Pepin, H. S. 1973. Variations in fruit-rot susceptibility of strawberry cultivars and selections as indicated by a postharvest screening technique. *Can. J. Plant Sci.* 53:341-343.
- Hill, A. T., and Binns, M. R. 1973. Effect of varying population density and size on laying performance. Pages 605-609 *in* Symp.: The effect of group size and space allowance on the performance and behaviour of the domestic fowl. *Proc. 4th Europ. Poult. Conf.* London.
- John, M. K. 1973. Cadmium uptake by eight food crops as influenced by various soil levels of cadmium. *Environ. Pollut.* 4:7-15.
- John, M. K. 1973. A batch-handling technique for hot-water extraction of boron from soils. *Soil Sci. Soc. Am. Proc.* 37:332-333.
- John, M. K., and Van Laerhoven, C. J. 1973. Application of a laboratory analog-digital computer system to data acquisition and reduction for quantitative analyses. *J. Assoc. Off. Anal. Chem.* 56:136-139.
- Waldern, D. E. 1973. Nitrogen utilization by lactating cows fed urea-treated corn silage or grass silage. *Can. J. Anim. Sci.* 53:333-337.
- Daubeney, H. A. 1973. The Haida red raspberry. *Proc. West. Wash. Hortic. Assoc.* 63:145-146.
- Daubeney, H. A. 1973. The current status of the Totem strawberry variety. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:15-17.
- Daubeney, H. A. 1973. Haida red raspberry variety. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:17-18.
- Daubeney, H. A. 1973. Haida raspberry. *Hort-Science* 8:381.
- Freeman, J. A. 1973. How serious a problem is fruit rot? Pages 131-134 *in* Panel: Does it pay: Strawberry fruit rot control and fumigation for nematodes? *Proc. West. Wash. Hortic. Assoc.* 63:129-138.
- Freeman, J. A., and Pepin, H. S. 1973. The answers to some strawberry fruit rot questions. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:60-64.
- Maas, E. F. 1973. Hydroponics? *Agrologist* 2(4):18.
- Maas, E. F., and Alkier, A. C. 1973. Why fertilizers don't work. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:54.
- Maurer, A. R. 1973. Processing carrot potential on Sumas sands. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:33-39.
- Maurer, A. R. 1973. Precision seeding of vegetable crops. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:41-47.
- Miltimore, J. E. 1973. Prevention of legume pasture bloat. Pages 1-4 *in* *Proc. Symp. on Ruminant Bloat*. Sponsored by Can. Feed Manuf. Assoc., Nov. 1973. Saskatoon, Sask.
- Taylor, D. K. 1973. What can we do about snow mold in British Columbia? *Turfline News* 6:3-5.
- Waldern, D. E. 1973. Effect of a mold inhibitor on quality of hay fed lactating cows. *Canadex* 410.60.

Miscellaneous

- Daubeney, H. A. 1973. The current status of the Totem strawberry variety. *Proc. West. Wash. Hortic. Assoc.* 63:105-106.

Research Station Kamloops, British Columbia

PROFESSIONAL STAFF

D. E. WALDERN, B.S.A., M.Sc., Ph.D.	Director; Beef cattle nutrition, forage utilization
W. B. HOLLIDAY	Administrative Officer
W. A. HUBBARD, B.S.A., M.Sc.	Forage management
A. MCLEAN, B.S.A., M.Sc., Ph.D.	Range and resource management
A. L. VAN RYSWYK, B.S.A., M.Sc., Ph.D.	Soil fertility and pedology

Departures

J. E. MILTIMORE, B.S.A., M.Sc., Ph.D.	Director
Appointed Director, Research Station, Agassiz, B.C., January 1973	
G. B. RICH, B.A.	Tick-host relationships
Died February 25, 1973	

INTRODUCTION

The Research Station at Kamloops, B.C., serves one of the most extensive ranching and farming areas of Canada. The Station specializes in integrated land use, including multiple use of grassland and forested ranges by cattle and deer as well as cattle-tree competition on logged and reforested areas. Studies on the production and utilization of cultivated forages grown under irrigation and on dryland and those with native forages growing on rangelands are an important part of the program.

An open, dry fall in 1972 and lack of snow resulted in severe winter injury to alfalfa stands, low soil-moisture reserves, a marked reduction in range forage production, high hay prices, and heavy culling of breeding herds by ranchers in the fall in 1973.

During the year, good progress was made in developing new clear-cut logging and bog meadow areas into new forage-producing research units. Classification studies of wet meadows in south central British Columbia disclosed a large landmass of excellent forage potential. The concentration of the toxic principle of timber milkvetch, miserotoxin, appears to be directly related to the amount of light received by the plant at various rangeland locations. Range cows help to prevent paralysis of their calves by reducing tick infestation through yarding and grooming them.

It is with deep regret that we report the passing in late February 1973 of Mr. George Rich, Entomologist. Mr. Rich devoted his career to the solution of problems arising from insect infestation of cattle. His work was highly respected by both cattlemen and scientists throughout North America.

Dr. J. E. Miltimore, Director of the Research Station, Kamloops, since September 1970, was appointed Director of the Research Station, Agassiz, B.C., in January 1973.

Some of the highlights of our 1973 research activities are presented in this report. Further information can be obtained from the Director, Research Station, Research Branch, Agriculture Canada, P.O. Box 940, Kamloops, B.C. V2C 5N5.

D. E. Waldern
Director

ENTOMOLOGY

Grooming and Yarding of Spring-born Calves Prevent Paralysis Caused by the Rocky Mountain Wood Tick

Ranchers regularly turn cow-calf herds onto tick-infested spring ranges with no perceptible danger of paralysis to the calves. Two maternal factors appear to protect young calves from exposure to tick infestations.

Under normal range conditions, groups of calves are congregated, or yarded, in sheltered or level areas, usually close to watering places, and left under the surveillance of a few sentinel cows while the rest of the cows move out to forage. The calves do not move about much, and this helps prevent heavy tick infestations.

Cows usually lick the entire bodies of their calves. This grooming was thought to remove any ticks that were on the calves and thus protect them from tick paralysis. To test this hypothesis, an experiment was conducted

with 10 cows and their calves under controlled conditions at the Station. Each of the 10 calves was infested with 50 ticks. Half of the calves were separated from their dams, except for a brief suckling period twice daily, whereas the remainder, the control group, had access to their mothers at all times. Five days after infestation, two calves in the separated group developed paralysis. One cow in the control group did not groom her calf and it also developed paralysis. The rate of tick infestation was 58% for the separated group and 6% for the control group.

LIVESTOCK MANAGEMENT

Response from Copper and Selenium with Vitamin E Injections to Cattle Pastured on Mineral and Organic Groundwater Soils

An experiment, using 127 cattle on one ranch over a 2-yr period and 82 cattle at two separate locations on a second ranch for 1 yr,

tested injections of copper (Cu) and injections of selenium (Se) with vitamin E, separately and in combination. Injections of 100 mg Cu as copper calcium edetate resulted in an increased overall daily gain of 118 g or 22%. The injections of Se and vitamin E did not significantly increase gain, and there was no synergistic effect when the two materials were given together. Forage growing on well drained soils had a Cu:Mo ratio of 1.9, which was almost treble the 0.7 ratio found in forage grown on the groundwater soil. On one ranch, Cu levels in hair from cattle injected only with Cu averaged 13.4 ppm Cu on an ovendry weight basis. This level was 54% higher than that found in hair from the control cattle. The mean concentration of Se in hair of cattle receiving Se with vitamin E was 60 ppm, which was not significantly different from the control of 58 ppm.

Miserotoxin Concentration of Timber Milkvetch Varies with Plant Location on Rangelands

Various estimates agree that 2 to 5% of the rangeland cattle in British Columbia are either chronically or fatally affected by timber milkvetch poisoning.

The variation in miserotoxin concentration of timber milkvetch, *Astragalus miser* Douglas ex Hooker var. *serotinus* (Gray) Barneby, was ascertained kinetically for 19 sites throughout British Columbia. Determinations were based on our recently developed methods of microisolation and derivatization of miserotoxin from fresh-frozen timber milkvetch samples. Timber milkvetch located in fescue grassland areas yielded the highest miserotoxin values (5.8 to 7.3% of the aerial shoots' dry matter), whereas the lowest peaks (3.1 to 4.3%) were recorded in the medium-canopied forests of the Douglas-fir - pine grass community. Peak toxicity in both the fescue grassland and Douglas-fir forest sites was associated with bud and prebud phases of growth with a decline occurring during the flower and pod stages. Subalpine, savannah, parkland, and semiopen areas of the montane forest exhibited intermediate miserotoxin maxima (4.3 to 5.8%). The data indicated that grazing should be avoided in the fescue grasslands in spring and minimized in exposed forest areas. The miserotoxin profiles also suggested that the toxicity of timber milkvetch is directly related to light intensity.

Effects of Climate on Forage Yields and Tree-ring Widths

On forested rangelands 109 annual forage yields from 12 locations were studied. Very dry springs and unusually low annual precipitation resulted in low forage yields. Dry summer months were associated with superior yields if the previous year had been wet. The relationship was not consistent, however, nor was there a consistent relationship between tree-diameter growth and climate based on monthly or seasonal temperature or precipitation records. Annual forage yields were 364 to 1,140 kg of ovendry matter/ha.

Forage yields on open rangelands, although only moderately associated with individual values for seasonal average temperature of total precipitation, could be estimated very well by all weather variables describing a 15-mo period. The 190 observations of yield from 16 open rangeland locations averaged 610 kg of ovendry matter with a minimum of 94 kg in 1967 and a maximum of 690 kg in 1965. Expressed as percentages of 1963 yields, annual forage weights averaged 116% and ranged from 53% to 214%. Such large variations as a result of fluctuations in climate are of obvious importance to graziers. The possibility that forage yields can be related to long-term variations in tree growth merits further study.

Productivity and Importance of Wet Meadows

Wet meadows were studied within an area bounded by the Monashee Mountains, Fraser River, International Border, and Williams Lake. Within this area, there are nearly 121,410 ha of wet meadowland. About 10% of the land surface in the North Thompson - Cariboo area, as estimated from maps and aerial photos, is meadowland. The herbage yields of 19 meadows sampled at elevations of 305 to 1,219 m varied from 504 to 10,008 kg/ha. Sedge (*Carex*) species were dominant on wet meadows, but associated plant species varied greatly.

Response of Reed Canarygrass to N, P, K, and Lime on 10 Organic Soils

Samples of 10 organic soils, all of the euic reaction class, were collected for growth-room fertilizer trials and subsampled for chemical analyses. One soil had a humic surface horizon and nine had mesic surface

horizons, but they represented a wide range of Humisol and Mesisol soil profiles.

Reed canarygrass responded markedly to N, P, and K applications on all soils but only to lime on the humic surface horizon that had the lowest extractable Ca value. Soil-nutrient sufficiencies based on dry-matter yields varied from 6 to 44% for N, 4 to 24% for P, and 10 to 17% for K. Sufficiencies based on nutrient uptake varied from 4 to 31% for N, 1 to 13% for P, and 3 to 21% for K.

Correlations between N response measurements (forage dry-matter yield and nutrient uptake) and degree of soil decomposition, as measured by (a) bulk density, (b) $\text{Na}_4\text{P}_2\text{O}_7$ -soluble organic matter, and (c) water-holding capacity, gave the highest positive values ($P < 0.05$) with (a) and (b) and the greatest negative value ($P < 0.05$) with (c). Rubbed fiber (volume basis) was also negatively correlated with N response measurements when the data for the humic surface horizon were omitted. Extractable P and K values were correlated positively, though not all were significant, with certain yield-response

measurements. Because reed canarygrass grown on all soils responded to applications of P and K, the extractable P and K values are considered to be in the deficiency range and serve as a basis for evaluating field situations.

Frequency of Cutting Irrigated Alfalfa Affects Stand, Productivity, and Longevity

The productive life of alfalfa fields in the interior of British Columbia is directly related to the time and frequency of cutting. In 1967, plots of Vernal and Lahontan alfalfa were established on irrigated land. During the next 4 yr, the plots were harvested two, three, four, five, or six times beginning May 6 and ending September 25. The highest 4-yr average yield of dry matter for Vernal was from the three-cut regime with 5.90 t/ha, whereas the highest for Lahontan, a southern-type alfalfa, was from the four-cut regime with 5.71 t/ha. A marked reduction in stand occurred in the second cutting year for both varieties when harvested six times during the season. Frequent cutting at the prebud stage was extremely detrimental to yield in subsequent years.

PUBLICATIONS

Research

Halford, S. A., Rich, G. B., and Bergis, I. 1973. A chrysomelid beetle defoliating big sagebrush in south-central British Columbia. *Can. J. Plant Sci.* 53:383-384.

McLean, A., and Smith, J. H. G. 1973. Effects of climate on forage yields and tree-ring widths in British Columbia. *J. Range Manage.* 26:416-419.

McLean, A., and van Ryswyk, A. L. 1973. Mortality in crested wheatgrass and Russian wildrye. *J. Range Manage.* 26:431-433.

Miltimore, J. E., Mason, J. L., McArthur, J. M., Strachan, C. C., and Clapp, J. B. 1973. Response from copper and selenium with vitamin E injections to cattle pastured on mineral and organic groundwater soils. *Can. J. Anim. Sci.* 53:237-244.

Rich, G. B. 1973. Grooming and yarding of spring-born calves prevent paralysis caused by the Rocky Mountain wood tick. *Can. J. Anim. Sci.* 53:377-378.

van Ryswyk, A. L., Hubbard, W. A., and Miltimore, J. E. 1973. Beef production potential and chemical composition of fertilized and unfertilized sedge hays grown on an organic soil of interior British Columbia. *Can. J. Anim. Sci.* 53:181-186.

Miscellaneous

McLean, A. 1973. Fall grazing of grasslands critical. *B.C. Cattlemen's Assoc. Newsl.* Oct. p. 4.

Neilson, C. L., and Rich, G. B. 1973. Livestock insect control. *B.C. Dep. Agric. Entomol. Branch Publ.* 73-4. 10 pp.

Rich, G. B. 1973. Grooming prevents tick paralysis. *Canadex* 420.16.

Rich, G. B., and Neilson, C. L. 1973. The recognition and life history of the insect and allied pests of livestock in British Columbia. *B.C. Dep. Agric. Entomol. Branch Publ.* 73-5. 33 pp.

van Ryswyk, A. L. 1973. Organic soil meadows. *Canadex* 510.

Waldern, D. E. 1973. Corn silage as the only roughage for lactating cows. Proc. Kamloops-Qkanagan Dairy Short Course. III. Nov. pp. 1-21.

Waldern, D. E. 1973. Nutrient requirements of dairy cattle—Adequacies and inadequacies. Proc. Pacific Northwest Anim. Nutr. Conf. 8:123-140.

Waldern, D. E. 1973. Selenium and vitamin E levels in roughages fed to beef cattle. B.C. Cattlemen's Assoc. Newsl. Oct. p. 5.

Research Station Sidney, British Columbia

PROFESSIONAL STAFF

H. ANDISON, B.S.A.	Director
R. M. ADAMSON, B.A., B.Sc., M.Sc.	Weed control and vegetables
R. G. ATKINSON, B.S.A., Ph.D.	Diseases of glasshouse crops
N. V. TONKS, B.S.A., M.S.	Insects of ornamentals
D. R. BERTOIA, B.S.A. (Production and Marketing Branch)	Officer-in-charge, Post-entry Quarantine Station
A. L. OLIVER, B.Sc. (Agr.) (Production and Marketing Branch)	Post-entry Quarantine Station

Departure

J. H. CROSSLEY, B.S.A., M.S.A. Retired March 1973	Ornamental crops
--	------------------

INTRODUCTION

The Research Station at Sidney, B.C., emphasizes research on problems of ornamental and greenhouse crops. Particular attention is being paid to the culture of greenhouse vegetables and ornamental nursery stock by use of soilless media in containers. Priority is also given to the propagation of superior clones of the Douglas-fir in cooperation with the forest industry. The work is rapidly expanding at the Post-entry Quarantine Station, which is operated jointly with the Plant Protection Division, Agriculture Canada.

Mr. J. H. Crossley retired in March 1973 after 35 yr of valuable service to agriculture. A pioneer in ornamental research work, he did more for the practical grower than anyone in Canada on bulbs, holly, fuchsias, tuberous begonias, and container growing of evergreen shrubs.

Requests for information or publications should be addressed to the Research Station, Research Branch, Agriculture Canada, 8801 East Saanich Road, Sidney, B.C. V8L 1H3.

H. Andison
Director

HORTICULTURAL CROPS

Greenhouse Tomatoes

Dolomitic lime in sawdust culture. A fine grind of dolomitic lime (65 AG) incorporated at 4 kg/m³ into sawdust prior to planting increased both early and total yields compared with the coarser (12 mesh and finer) grade normally used by growers for the "premix" method of feeding. This increase was likely due to the ready availability of Ca and Mg because mean levels determined by weekly monitoring of solution extracted from the root zone were approximately twice as high (Spurway method) as those in the coarser-grade plots. No yield increases resulted from application rates above 4 kg/m³.

Slow-release fertilizers in sawdust culture. In an experiment with a fall crop of tomatoes, three Osmocote (Sierra Chemical Co.) formulations and MagAmp (W. R. Grace and Co.) were each mixed with the sawdust, dolomitic lime, and minor elements before transplanting. The yields were compared with those from complete nutrient-solution feeding throughout the season. Only Osmocote 14-14-14 at 12 kg/m³ with subsequent watering produced yields comparable with those from complete nutrient-solution feeding. Yellowing of the upper part of the plants developed, however, revealing N deficiency and indicating that this formulation might prove unsuitable for a longer-season crop. At equivalent levels of N, the other slow-release formulations resulted in less vigorous growth and lower production.

Acceleration of fruit ripening by ethephon sprays. Overall sprays of ethephon (Ethrel; Amchem Products Inc.) at 1,200 ppm applied Nov. 2 to a fall crop of Vendor tomatoes grown in sawdust accelerated fruit ripening. Of the balance of the crop, 97% was picked within 11 days of spraying compared with 54% from untreated plots. Such a treatment would permit crop removal 2 wk earlier than usual with a marked saving in heating costs, and would provide more time for greenhouse repairs and to prepare for the next crop. Similar rates applied in July accelerated ripening of the last part of the spring crop; significantly more ripe fruit was harvested within 3 days of spray treatment. Applications at 2,400 ppm failed to accelerate the rate of ripening further.

Fusarium wilt in sawdust medium. Local production of greenhouse tomatoes in sawdust that is trickle irrigated with nutrients may suffer decreased yields as a result of contamination of the growing medium with *Fusarium oxysporum* Schlecht. f. *lycopersici* (Sacc.) Snyder & Hansen. On several spring and fall crops grown in naturally infested sawdust, applications of the systemic fungicides benomyl 50 WP and thiophanate-methyl 70 WP reduced the severity of disease symptoms and increased marketable yields to economic levels. Best results were obtained when benomyl at 100 ppm (wt/vol) and thiophanate-methyl at 150 ppm were incorporated into the sawdust before planting. Similar rates were not as effective when

applied by trickle irrigation in split applications after planting. When application was delayed until wilting occurred, yield increases were minimal.

Woody Plants

Propagation of woody plants. Softwood cuttings of eight varieties of flowering cherry taken during early July rooted better than hardwood cuttings taken immediately after leaf drop in November. The best method was to wound each softwood cutting before dipping it in IBA (indolebutyric acid) hormone powder. Then the cuttings were placed in a 1:1 peat-sand rooting medium under artificial light in a plastic-covered enclosure and held at about 15°C for 5 wk.

Cooperation was continued with MacMillan Bloedel Ltd. and Pacific (CPR) Logging Co. in propagation experiments using about 20,000 Douglas-fir cuttings taken from "plus" or selected clonal trees. Best results were obtained during January when heel cuttings were dipped in IBA hormone powder at 2,000 ppm for 5 s and then placed separately in a 1:1:1 sand-peat-perlite rooting medium in small plastic containers in a shade-house equipped with a mist system and at a minimum temperature of 21°C. Ornamental blue spruce, *Picea* sp., were also rooted by this method.

Post-entry Quarantine Station. Introductions in 1973 included 92 clones of *Vitis* and 198 clones of tree fruits, of which 85% were foreign in origin. Seventy clones were found to be infected with virus. At present, 260 clones have been indexed and found free from known viruses. These clones are grown in isolation in the repositories at the Station, and lists of available varieties have been mailed to workers in research, extension, universities, and industry across Canada.

Control of The Greenhouse Whitefly

On tomato. Naled 8.6 EC and resmethrin formulations containing 0.69% toxicant, often used to control the greenhouse whitefly, were tested for their effect on fruit set of the greenhouse tomato cultivar Vantage. Naled was applied to heating pipes overnight at 9 g toxicant/100 m³, and as a high-volume foliage spray at 1.25 ml/litre. Resmethrin was applied as an aerosol overnight at 100 ml/100 m³ and as an ultralow-volume spray. All treatments were applied concurrently five times at 5-day intervals starting when the second truss was in bloom, and continuing through the blooming period of the fourth truss. Resmethrin treatments caused no significant change in marketable yields. Naled, however, reduced the yield by 26% as a pipe application and by 46% as a foliage spray.

On poinsettia. Vydate (DuPont of Canada) at 0.25, 0.5, 1.0, and 2 g toxicant/litre applied as a soil drench of 114 ml per 18-cm pot on poinsettia cultivar Dark Red Hegg gave increasingly effective control of greenhouse whitefly scales as the concentration of Vydate increased. Complete control occurred at a concentration between 1 and 2 g/litre.

Control of Common Yarrow in Turf

Common yarrow, a persistent perennial weed of lawns that is resistant to 2,4-D, was well controlled by two late-spring applications 2 wk apart of mecoprop at 1.68 kg/ha (1.5 lb/ac), when rated 11 wk after the initial treatment. Two applications of dicamba at 0.56 kg/ha (0.5 lb/ac), also at 2-wk intervals, gave more effective early control, but the yarrow recovered better than with the mecoprop treatments. A single application of picloram at 0.56 kg/ha (0.5 lb/ac) eradicated the weed, but this herbicide is not registered for use on lawns.

PUBLICATIONS

Miscellaneous

- Crossley, J. H. 1973. Alternatives to soil in containers. *Am. Nurseryman* 137:11.
- Crossley, J. H. 1973. Fertilizer recommendations for holly trees. Supplement to Holly Culture in British Columbia. H.C. 79. B.C. Dep. Agric., Victoria, B.C. 4 pp.
- Mason, E. B. B., and Adamson, R. M. 1973. Trickle watering and liquid feeding system for greenhouse crops. *Can. Dep. Agric. Publ.* 1510. 19 pp.
- Tonks, N. V. 1973. Holly insects and their control. Supplement to Holly Culture in British Columbia. H.C. 79. B.C. Dep. Agric., Victoria, B.C. 4 pp.

Research Station

Summerland, British Columbia

PROFESSIONAL STAFF

D. V. FISHER, B.S.A., M.S.A., Ph.D., F.A.S.H.S.	Director
E. F. BELL	Administrative Officer
J. C. LAVERY, B.Sc., B.L.S.	Librarian

Agricultural Engineering Section

A. D. McMECHAN, B.A.Sc.	Head of Section; Sprayer and fruit-handling equipment
P. PARCHOMCHUK, B.A.Sc., M.S.	Harvesting equipment

Animal Science Section

J. M. McARTHUR, B.A., M.A., Ph.D.	Head of Section; Bloat research in cattle
R. E. HOWARTH, ¹ B.S.A., M.S., Ph.D.	Biochemist

Entomology Section

H. F. MADSEN, ² B.A., Ph.D.	Head of Section; Integrated control
F. L. BANHAM, B.A.	Stone-fruit insects
R. S. DOWNING, B.A., M.S.	Control of mites
A. P. GAUNCE, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry
R. D. McMULLEN, B.Sc., M.Sc., Ph.D.	Bionomics of pear psylla
J. D. MACNEIL, B.Sc., M.Sc., Ph.D.	Pesticide and environmental chemistry
C. V. G. MORGAN, B.S.A., M.Sc.	Control of grape insects and mites
M. D. PROVERBS, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method

Food Processing Section

J. A. KITSON, B.A., M.S.	Head of Section; Process and product development
J. F. BOWEN, B.S.A., M.S.A., Ph.D.	Microbiology
D. BRITTON (Miss), Dip. H.Ec.	Home economist
H. A. BUTTKUS, B.S.A., M.A.	Biochemistry
D. R. MACGREGOR, ³ B.S.A., M.S., Ph.D.	Biochemistry and microbiology
D. F. WOOD, B.Sc., M.Sc., Ph.D.	Biochemistry

Soil Science Section

J. L. MASON, B.S.A., M.Sc., Ph.D.	Head of Section; Plant nutrition
F. M. CHAPMAN, B.S.A.	Cereals, forage crops
D. S. STEVENSON, B.S.A., M.S., Ph.D.	Soil physics and irrigation

Plant Pathology Section

M. F. WELSH, ⁴ B.S.A., Ph.D.	Head of Section; Virus diseases of pome fruits
A. J. HANSEN, ⁵ Dip. Agr., M.Sc., Ph.D.	Virus diseases of stone fruits and grapes
L. E. LOPATECKI, ⁶ B.A., B.S.A., M.S.A., Ph.D.	Parasitic tree-fruit diseases
D. L. MCINTOSH, B.S.A., Ph.D.	Parasitic tree-fruit diseases
R. M. ROSHER, B.A., M.A.	Parasitic tree-fruit diseases

Pomology Section

S. W. PORRITT, B.S.A., M.S., Ph.D.	Head of Section; Fruit harvesting and storage
L. G. DENBY, B.S.A., M.S.A., F.R.H.S.	Rootstocks—grapes, peaches
K. O. LAPINS, Agr., M.S.A., Ph.D.	Fruit breeding and hardiness
N. E. LOONEY, B.S., M.S., Ph.D.	Agrometeorology, growth regulants
M. MEHERIUK, B.Sc., B.Ed., M.Sc., Ph.D.	Postharvest physiology, biochemistry

VISITING SCIENTIST

National Research Council postdoctorate fellow, 1973

S. K. SARKAR, Ph.D.

Biochemistry, animal nutrition

¹On work transfer from Research Station, Saskatoon, Sask., from June 1972 to September 1973.

²On 10-mo work transfer to Fruit and Food Technology Research Institute, Stellenbosch, South Africa, from September 1973.

³On loan to CIDA, as head of Food Science Department, University of Ghana, from October 1971 to July 1973.

⁴On 1-yr work transfer to New York State Agricultural Experiment Station, Geneva, from September 1973.

⁵On 1-yr transfer of work to Biologische Bundesanstalt, Braunschweig, Germany, from July 1973.

⁶On transfer of work to Department of Scientific and Industrial Research, Auckland, N.Z., from September 1972 to September 1973.

INTRODUCTION

This report deals with some aspects of a multidisciplinary program designed to serve the needs of the British Columbia tree-fruit and grape industry. Emphasis is placed on research to lower costs of production through improved insect and disease control methods, closely planted orchards, reduction of crop losses from physiological disorders of fruit, broadening the base of fruit processing, and development of improved orchard equipment.

Research scientists have worked with provincial and federal committees and committees of the British Columbia Fruit Growers' Association. The B.C. Department of Agriculture Tree Fruit Production Guide is a joint production of provincial officials and members of the staff of the Research Station, Summerland, B.C.

The serious apple-breakdown problem that affects Spartan, our third most important cultivar, has been demonstrated to be essentially a calcium-related disorder. As a result of findings at the Station, the entire 1974 Spartan crop will be dipped at harvest in a 3% calcium chloride solution.

In September, the cattle-bloat program, Dr. R. E. Howarth, and Dr. S. Sarkar were transferred from here to the Research Station at Saskatoon. Although we were sorry to see this program leave the Station, we benefited from the facilities made available to accommodate the pesticide chemists and the Plant Pathology Section, whose building was destroyed by fire in June.

For further information on the scientific and industry-related programs of the Station, correspondence should be addressed to Research Station, Research Branch, Agriculture Canada, Summerland, B.C. V0H 1Z0.

D. V. Fisher
Director

AGRICULTURAL ENGINEERING

Vineyard Sprayer Development

During the last 2 yr, experiments were conducted to determine the minimum airstream requirements for efficient spray application in vineyards. It was concluded that a properly directed airstream with an average velocity of 160 km/h and a volume of 84 m³/min per side should give good spray distribution through most vines. In field trials in 1973, a prototype sprayer with these specifications gave slightly poorer spray-deposit distribution and control of Virginia-creeper leafhopper than a conventional air-blast orchard sprayer producing an airstream with an average velocity of 192 km/h and a volume of 185 m³/min per side. Further work is required to determine the airstream direction that will give the best penetration of the vines.

Equipment for Dispersal of Sterile Codling Moths from a Ground Vehicle

Equipment was constructed for release of sterile codling moths from a ground vehicle (dune buggy). It was similar to that constructed previously for release from the

helicopter, but the feed rate had to be much slower because the ground speed was limited to 11 km/h. When very low feed rates were required, the feed-belt motor was operated intermittently by a cam-operated switch. A small fan carried the insects clear of the vehicle and under the tree canopy as they were released.

Filtration of Water for Trickle Irrigation

Filters of several types were tested in the laboratory and the field to determine their suitability for use in trickle irrigation systems. Sand, screen, and cartridge types were all effective in removing visible particles from the water. The cartridge filters plugged rapidly and were more difficult to clean than the other types. An automatically self-cleaning screen, which was constructed in our shop, performed satisfactorily all season.

Even with the best filtering there was still a problem. During the season a brown sludge, apparently a very fine silt, accumulated in the irrigation lines and eventually blocked the emitters, which then had to be cleaned out or replaced. Flushing the lines at 2-wk intervals did not help. Further work is required to overcome this problem.

ANIMAL SCIENCE

Pasture Bloat

Some legumes are nonbloating because they contain both hydrolyzable and condensed tannins that precipitate the bloat-inducing proteins. Of the birdsfoot trefoils, the European upright types contain tannins, but the spreading types do not. The latter are nonbloating because of low protein content.

Fraction I protein, which is 30–50% of the soluble protein in alfalfa, is the main component responsible for rumen foams in bloat. At least two Fraction II proteins contribute to the foams, but they are present in only relatively small quantities.

Alfalfa Winter Killing

In evaluation tests at Creston, B.C., winter survival of the newly licensed and introduced cultivars Algonquin and Angus equaled that of Vernal. Algonquin, a standard regrowth type, was hardier than Saranac and showed rapid regrowth characteristics. Angus, which is similar to Saranac in growth habit, was equal to it in winterhardiness. At the Station, no differences in stand densities were observed between the two cultivars.

ENTOMOLOGY

Codling Moth

Autocidal control. Moths that had been sterilized by gamma irradiation were released into orchards from a Volkswagen dune buggy fitted with wide low-pressure tires. This method of moth dispersal was as effective as release from a helicopter and cost 70% less. Substitution of rapeseed meal for casein as a protein source in the larval rearing medium significantly reduced production costs.

Sex attractant. Continued experiments using traps baited with Codlemone (Zoëcon Corp.) to determine the need for and timing of sprays to control codling moths indicated the advantages of this technique. Treatments were advised only when more than two moths were captured per week per trap. In six orchards an average of 1.8 sprays were required compared with an average of 2.2 sprays in 1972. Codling moth injury in the six orchards was less than in 1972.

Fruittree Leafroller

Sex attractants and traps. Tests of synthetic sex attractants for fruittree leafrollers demonstrated that formulations of 11-tetradecenyl acetate containing both the *cis* and *trans* isomers plus dodecyl acetate were more effective than formulations with only *cis* or *trans* isomers. Of six trap designs tested, the Pherotrap 1C (Zoëcon Corp.) was the most effective.

Cherry Fruit Flies

Traps and attractants. Pherocon 1CPY traps baited with Mago Attractant (Zoëcon Corp.) were much more attractive to western and black cherry fruit flies than Sectar 1 traps baited with Seclur (3M Co.) or standard yellow sticky boards. Mago Attractant significantly increased the ratio of female to male moths caught.

Chemical control. A single application of dimethoate 40 EC at 2.8 litres/ha 6 days after the trapping of the first adult flies provided excellent control of the western cherry fruit fly. In the same experiment, treatment of the lower half of the tree canopy gave results equal to treatment of the whole tree canopy. Painting undiluted dimethoate 40 EC in 15.2- and 30.6-cm (6- and 12-in.) bands on the trunks, scaffold, or secondary limbs of cherry trees did not adequately control the western cherry fruit fly and was phytotoxic to foliage immediately above the painted bands.

Orchard Mites

Biological control. In 1972, an organophosphate-resistant strain of *Amblyseius fallacis* (Garman) was released in an experimental orchard. By early autumn, the number of *A. fallacis* had declined drastically and the number of *Typhlodromus occidentalis* Nesbitt, a native predator, had increased. In 1973, intensive sampling of the orchard recovered only one specimen of *A. fallacis*. Apparently, this predator was unable to become established and thrive in the dry Okanagan climate.

Chemical control. Delayed dormant applications of endosulfan plus oil or ethion plus oil gave excellent control of both the pearleaf blister mite and the pear rust mite. Citrazon (Nippon Soda Co.), SD 14114 (Shell Canada), and R28627 (Stauffer Chemicals) gave effective control of the European red mite

and were low in toxicity to predaceous mites. UC44858 (Upjohn Canada) was very effective against the European red mite but highly toxic to predaceous mites. The fungicide TCMTB (Buckman Laboratories), reportedly effective against mites, was not effective against the European red mite.

Pear Pests

Pest management. A pilot study of pest management was established in eight commercial pear orchards. Population levels of important pests including the pear psylla, fruittree leafroller, pearleaf blister mite, pear rust mite, European red mite, McDaniel spider mite, and codling moth plus beneficial predaceous species were monitored throughout the crop season. On the basis of population indexes and the best estimates of population level – economic injury thresholds, growers were advised of the need for and the most economic control measures. The costs of samples and prescribed control measures were obtained and compared with cost estimates of the control program that each grower would normally have used. In all of the orchards, fewer applications of pesticide were used than normal, and the savings in costs were greater than the cost of the pest monitoring – advisory service.

Pesticide Residues

Fumigation with ethylene dibromide has been shown to kill eggs of the European red mite and adults of the McDaniel spider mite on apples intended for export to South Africa. Aeration of the fruit after fumigation is required to dissipate the sorbed fumigant to levels acceptable for both inorganic and organic bromides. Inorganic bromide residues were reduced below the tolerance of 10 ppm by aeration at 13°C for 2 days. However, in order to maintain fruit quality and reduce organic bromide residues below the tolerance of 0.1 ppm, aeration at 13°C for 3 days followed by cold storage at 1°C for 60 days or aeration for 7 days and cold storage for 50 days is required.

FOOD PROCESSING

Vacuum Aroma Concentration

Operating characteristics of a vacuum aroma concentration column measuring 10 cm × 3 m (4 in. × 10 ft) were improved by

the addition of a vapor cooler on the downstream side of the vacuum pump and by the installation of new cold traps to condense the concentrated aroma volatiles. The new stainless-steel traps are simply and economically cooled by immersing them in alcohol baths that are cooled to -75°C by direct expansion of liquid nitrogen into open copper coils. Recording instrumentation was provided for most of the column's operating parameters, and optimum conditions for concentrating apple essence and water-soluble orange essence were determined. The loss of aroma volatiles in column bottoms and in the vapor-liquid separator did not exceed 5% of the feed for the essences tested. A large part of the lost material was ethanol, which is not a significant factor in fruit aroma.

Freezing and Reconstitution of Institutional Foods

A system of freezing and reconstituting a complete menu was developed for a 200-bed hospital in a cooperative project involving the Penticton Regional Hospital, Department of National Health and Welfare, B.C. Hospital Insurance Commission, and Canada Department of Agriculture.

In one phase of the study carried out at the Station, 92 menu items that had been prepared and frozen at the Penticton Regional Hospital were evaluated by an 8-member taste panel selected from the Food Processing Section. Samples that had been thawed by holding for 48 h at 3°C were served onto chilled plates along with other meal components to make up a constant serving weight of 220 g. Plated samples were covered and held a further 90 min before they were reconstituted in a convection oven for 20 min at 150°C. Heating rates were measured for the 30 samples that had been judged to be the slowest heating because of their size, shape, or composition. All properly thawed samples had reached an adequate serving temperature within the time that they would normally be served and eaten. All categories of foods tested were rated acceptable or better with the exception of vegetables. After the first evaluation, the vegetable preparation system was changed and these foods as now served are also rated acceptable.

Three systems of freezing 12-portion servings of four items from the hospital menu were evaluated. Samples were frozen at -18°C in still air and at -23°C and -40°C in

air-blast freezers. Although freezing was much faster at the lower temperatures in moving air, panel evaluation of texture, flavor, and color indicated no significant differences between samples frozen by the three systems.

Wine Trials from Grape Varieties

One hundred and twenty-one samples of grapes of the 1972 crop made up of 37 established varieties and 84 new crosses from the Station were processed into wine. As in previous years, an excellent red wine, similar to Cabernet Sauvignon, was made from Seibel 9549. A taste panel at Prosser, Washington, rated this wine as superior to Washington State Cabernet. Seibel 9110 (Verdelet), which has tended to a neutral flavor, gave a much higher quality white wine when fermented in contact with the skins for 24 h, rather than when the freshly pressed juice was fermented. Baco Noir yielded a very deep red Burgundy-type wine of moderate acidity and excellent body. The wine from Schuyler was a rather light red, but had excellent flavor and aroma. Hungarian Riesling, as in previous tests, gave a very fine white wine when freshly pressed juice was used. When the grapes were fermented in the skins for 24 h, the wine had a more pronounced flavor suggesting muscat and a slightly darker color.

Of the new crosses, 20 were worth further study. Some of the red crosses gave full-bodied, deeply colored wines possibly superior to De Chanunac or Baco Noir, whereas some of the white wines were as good as or better than Verdelet. Several crosses were very highly aromatic suggesting muscat, and they may be useful as specialty types.

The processing program was modified to facilitate the handling of the large number of samples. It involved crushing the fruit, followed by the addition of ascorbic acid and sulfur dioxide, and freezer storage. When the fruit was thawed, it showed few if any undesirable changes and fermentation was normal. Now laboratory fermentations can be carried out at any time during the year, rather than only at harvest time.

PLANT PATHOLOGY

Brown Line Decline in Apple Trees

The sensitivity to brown line decline virus (BLDV) of Ottawa clonal (OC) rootstocks 3, 5, 7, 8, 11, and 12 and of Ottawa hybrid (OH) rootstocks 1 to 6 was tested with two isolates. The effects of BLDV-1 and BLDV-2 differed in severity and sometimes in type. OC-3, 7, and 12 were affected severely by at least one strain. OC-5 was affected only mildly by BLDV-1, and OC-11 was not sensitive to either. All healthy and virus-infected scions formed a deep groove at their union with OC-8, but no necrosis or pitting.

Cherry Rasp Leaf Virus (CRLV) in Native Hosts

Common orchard weeds such as dandelion, *Taraxacum officinale* Weber, and broad-leaved plantain, *Plantago major* L., can be naturally infected with CRLV. The virus is transmitted by seed in dandelion. Apple is susceptible to CRLV.

Target Spot Disease of Cherry Caused by Tomato Bushy Stunt Virus (TBSV)

The biophysical characteristics of British Columbia isolates of TBSV are similar to those of Ontario isolates. Scattered infected trees, without evidence of orchard spread, have been found in all the main cherry-growing districts of the Okanagan and Similkameen valleys. The virus was not recovered from orchard soil. Inoculation of various *Prunus* spp. indicated that the virus moves very slowly in a tree.

Treatment of Apples to Eliminate Fire Blight Bacteria

Assays of fruit that had been artificially contaminated with *Erwinia amylovora* (Burr.) Winslow et al. disclosed that the bacteria survive on fruit surfaces for only a short period at summer temperatures. *E. amylovora* were not recovered from the surface of apples taken from trees growing adjacent to severely affected pear trees. Dipping mature fruits for 6 min in either 1 M acetic acid or a 74% mixture of alcohols inactivated bacteria that had been applied to the surface of the fruit.

Gloeosporium fructigenum Berk. [*Glomerella cingulata* (Stonem.) Spauld. & Schrenk], *G. perennans* Zeller & Childs, and *G. album* Osterw. cause rots of apples in storage. Only *G. fructigenum*, under favorable conditions, attacks ripening fruit in orchards. The ability of *G. fructigenum* to attack immature fruit appeared to be mainly physical and depended primarily on continuous moisture and warm temperatures.

When spores of *G. fructigenum* were placed on the apple surface, they germinated and formed appressoria within 6–8 h. All nutrients then transferred from spores to appressoria; an infection peg appeared and forced its way through the epidermis into cortical tissue. This mechanism was independent of external nutrients because additions of carbohydrates or amino acids to the infection court made no difference to the rate of infection. Unlike the other two fungi, *G. fructigenum* produced a very active amylase in culture and degraded starch grains rapidly in rotted tissue. No differences were detected in the ability of the three fungi to detoxify plant polyphenols.

Crown Rot of Apple Trees

Behavior in soil. Sporangia and oospores of *Phytophthora cactorum* (Leb. & Cohn) Schroet. persisted for a considerable time in soil at temperatures and soil water contents likely to prevail during a growing season. Infection of apple seedlings by *P. cactorum* can occur in relatively dry soil, i.e., when the soil water content is well below the water-holding capacity. Infections are more numerous when the soil water content is above field capacity. Direct observation of sporangia and oospores in soil disclosed that both spore types germinate in soil to produce sporangia at the end of short germ tubes. Such sporangia persist for a rather long time in soil and germinate either directly with a germ tube or indirectly by the production of zoospores.

Chemical control. Dexon (Chemagro Corp.) provided better protection from crown rot infections than maneb when these materials were injected into the soil around the crowns of young trees.

Storage Humidity and Breakdown in Spartan Apples

High humidity provided by storing Spartan apples in perforated polyethylene box liners is conducive to the development of breakdown. To determine the relationship of the level of humidity to the incidence of breakdown, Spartan apples were stored in 291-litre (8-bu) cabinets in which the relative humidity (RH) was maintained at approximately 75, 80, 90, and 95% and the temperature was 0°C. After 6-mo storage, breakdown averaged about 5% in the two lowest humidities, but affected 30% of the fruit stored at 90% RH and 40% of the fruit stored at 95% RH.

Postharvest Treatments to Control Breakdown in Apples

After a number of postharvest treatments, Spartan apples were stored at 0°C in perforated polyethylene box liners to provide a RH of 92–94%, which is conducive to breakdown. Postharvest dips in diphenylamine had no effect on breakdown, and in other treatments the inclusion of potassium permanganate to absorb ethylene did not reduce the disorder. Dipping fruit in 200 ppm gibberellic acid, or holding fruit for 2–3 days at 21°C before cold storage, reduced breakdown significantly. The most effective chemical treatment was a dip in 4% calcium chloride solution, which resulted in 7% breakdown compared with 28% in the controls. Comparable fruit stored in open boxes at about 80% RH had less than 1% breakdown.

Changes in Chlorogenic Acid Levels During Growth and Maturation of Spartan and Golden Delicious Apples

The tendency for enzymatic browning of apple tissues varies with the variety and maturity of the fruit. A study was made of Spartan and Golden Delicious apples during growth and maturation to determine the relationship of phenolic constituents to the observed differences in the rate of browning of tissue. By thin-layer chromatography, chlorogenic acid was found to be the main phenolic component of peel and flesh. Chlorogenic acid concentration in young fruit of both cultivars about 6 wk after bloom was 6.0–6.5 mg/g in the peel and about 4 mg/g

in the flesh. These levels decreased during the growth of Spartan fruit to an average of 2.7 mg/g in the peel and 0.9 mg/g in the flesh at harvest. Chlorogenic acid in corresponding tissue of Golden Delicious was about half these values in mature fruit. These data are consistent with observations that resistance to tissue browning increases as the fruit matures and that mature Golden Delicious apples are much more resistant to browning than Spartan apples.

Mutants of Spurred Growth in McIntosh Apple

The first four natural mutants of spur-type (compact growth) McIntosh apple completed their 5th yr in two experimental plantings. Trees of Starkspur, Dewar, and MacSpur measured 70–80% the size of the standard McIntosh, whereas those of Morspur were 60% the size of the standard. The four selections showed variable degrees of spurri-ness. The ratios of the total number of spurs to the total number of 1-yr shoots on 3-yr-old branches averaged 30.1, 27.3, 15.8, 11.4, and 5.9 for MacSpur, Morspur, Dewar, Starkspur, and the standard. Trees bore their first normal crop in 1973. The yield was 11.8–20.1 kg/tree, which amounted to about 0.51 kg/cm² of trunk cross-sectional area. The fruit of the selections was typical of the cultivar; the skin color was as good as, or better than, the standard.

Degrees of Tree Spurri-ness in Various Apple Progenies

Crosses with McIntosh, Wijcik (spur-type) mutant as the male parent, which were made both here and at East Malling Research Station, Kent, England, segregated 40–45% of the seedlings with very distinct compact and spurred growth. A hypothesis is suggested that compact growth habit in crosses involving McIntosh, Wijcik as a parent is controlled by a dominant gene *Co*, which arose as a natural mutation in McIntosh (Lapins and Watkins).

Tree growth type was also studied in 59 other progenies in orchard trees at fruit-bearing age. No definite segregation for growth types was observed. Rather, a continuous range from trees with no or very few spurs to trees with a great abundance of spurs and compact growth was recorded. In certain progenies, 30–56% of the trees had growth characteristics comparable with those

of the spur types of commercial cultivars. Among parents that induced spurri-ness in the progeny, Alkmene, Toshkee, and Melba were prominent.

Growth Regulators to Control Fruit Drop and Ripening of Apples

Alar (UniRoyal Chemicals) effectively suppresses ethylene production by apples and thus delays ripening and abscission of the fruit. Conversely, ethephon (Ethrel; Amchem Products Inc.) is an ethylene generator, which can be used to advance fruit ripening and harvest date. Alar applied in midsummer followed by ethephon applied to advance harvest promises advantages that were explored in recent experiments. For example, the suitability of various auxinic stop-drop treatments for use with ethephon was found to depend on the Alar pretreatment. Better drop control was achieved and lower levels of 2,4,5-TP (fenoprop) could be used when Alar had been applied. When the combination was used, apples ripened with the ethephon–auxin technique were firmer than when Alar was excluded. Finally, red color development was marginally improved by Alar and greatly improved by the ethephon–auxin ripening technique. These effects were found to be additive, which can be particularly advantageous if early harvest is contemplated.

The Physiology of Softening of McIntosh Apples

Ethylene production by ripening McIntosh apples held at 20°C was reduced dramatically in fruits treated in midsummer with Alar. Alar-treated fruits were initially firmer than untreated fruits, but the rate at which softening occurred was not found to be related to ethylene production rates. When a steady stream of 10% carbon dioxide in air was applied to these ripening fruits, ethylene production by the untreated fruit was substantially reduced and even further reduced in the Alar-treated fruits. In both lots, this gassing treatment markedly reduced the rate of fruit softening. We have concluded that softening at 20°C is not related to the rate of endogenous ethylene production once ripening has started.

Redhaven and Fairhaven peaches on seedling roots were planted in 1967 at a spacing of 3.7×5.5 m (12×18 ft) and trained to two-arm palmettes. In 1973, these trees were subjected to severe pruning and water-jet blossom thinning, followed by hand thinning to 25-cm (10-in.) spacing. Yields approximated 67 t/ha (30 tons/ac). Fruits were large and of excellent quality with less than 1% splits. Corresponding standard trees yielded 25.56 t/ha (11.4 tons/ac) and had 18–27% splits.

Performance of Six Apple Cultivars on Three Rootstocks

In 1966, Harrold Red Delicious, Golden Delicious, Spartan, McIntosh, Tydeman Early, and Quinte, budded on M 9, M 26, and M 7, were combined in a dense planting at a spacing of 2.44×4.57 m (8×15 ft).

To 1973, the most productive cultivar has been Golden Delicious with a cumulative mean of 109.78 t/ha (48.87 tons/ac), followed by Spartan 90.22 (40.16), McIntosh 76.04 (33.85), Harrold Red Delicious 74.04 (32.96), Quinte 54.32 (24.18), and Tydeman Early 47.89 (21.32).

The most productive rootstock disregarding cultivar differences has been M 7 with a cumulative mean of 84.13 t/ha (37.45 tons/ac), followed by M 26 with 74.98 (33.38), and M 9 with 71.88 (32.00).

The most productive rootstock combination for each cultivar has been M 26 for Golden Delicious with a cumulative mean of 130.09 t/ha (57.91 tons/ac), M 7 for Spartan 108.86 (48.46), M 26 for McIntosh 83.16 (37.02), M 9 for Harrold Red Delicious 83.54 (37.19), M 7 for Quinte 72.15 (32.12), and M 7 for Tydeman Early 52.59 (23.41).

Thickeners and Surfactants in Dips to Prevent Spartan Breakdown

Dips in calcium chloride solution were effective in reducing breakdown in Spartan apples. However, if the calcium from dips can be increased still more, breakdown can be more certainly prevented. In an experiment to improve calcium uptake from dips, two thickeners were very effective. Undipped fruit had 204 ppm calcium in fruit flesh. Fruit dipped in 4% calcium chloride solution had 282 ppm calcium. Arrowroot thickener added to the dip increased fruit calcium to 421 ppm and Kelzan M thickener brought the calcium to 634 ppm. In contrast to thickeners, surfactants added to the dip reduced fruit calcium to 240 ppm.

Trickle Irrigation

Spacing of emitters (drippers) for trickle irrigation was found to depend on water distribution properties of soils, and the soil becomes the distribution system from each point of water application. Although understanding of water movement in the soil from continuous-point application is increasing, problems such as the plugging of drippers by silt and algae are hard to solve and responsible for the slow acceptance of the system by growers. A bulletin describing the design and appropriate dripper spacings for trickle watering has been released.

Water Retention for Plants in Soil-Peat Mixtures

Additions of 1–5% by weight of commercial peat moss increased the percentage of water content at all soil-water suctions up to 15 bars. Peat also decreased the bulk density of the soil. The net result was that retention of plant-available water was increased in loamy sand, decreased in silt, and unchanged in sandy loam.

PUBLICATIONS

Research

Banham, F. L. 1973. An evaluation of traps for the western cherry fruit fly (Diptera: Tephritidae). J. Entomol. Soc. B.C. 70:13-16.

Erskine, J. M. 1973. Association of virulence characteristics of *Erwinia amylovora* with toxigenicity of its phage lysates to rabbit. Can. J. Microbiol. 19:875-877.

- Erskine, J. M. 1973. Characteristics of *Erwinia amylovora* bacteriophage and its possible role in the epidemiology of fire blight. *Can. J. Microbiol.* 19:837-845.
- Hironaka, R., Miltimore, J. E., McArthur, J. M., MacGregor, D. R., and Smith, E. S. 1973. Influence of particle size of concentrate on rumen conditions associated with feedlot bloat. *Can. J. Anim. Sci.* 53:75-80.
- Howarth, R. E., McArthur, J. M., and Goplen, B. P. 1973. Bloat investigations: Determination of soluble protein concentrations in alfalfa (*Medicago sativa* L.). *Crop Sci.* 13:677-680.
- Howarth, R. E., McArthur, J. M., Hikichi, M., and Sarkar, S. K. 1973. Bloat investigations: Denaturation of alfalfa Fraction II proteins by foaming. *Can. J. Anim. Sci.* 53:439.
- Madsen, H. F., and Vakenti, J. M. 1973. Codling moth: Use of Codlemone-baited traps and visual detection of entries to determine need of sprays. *Environ. Entomol.* 2:677-679.
- Madsen, H. F., Vakenti, J. M., and Borden, J. H. 1973. Attraction of virgin females and synthetic sex attractants to the fruittree leafroller, *Archips argyrospilus* (Lepidoptera: Tortricidae). *Can. Entomol.* 105:921-924.
- Madsen, H. F., and Vakenti, J. M. 1973. The influence of trap design on the response of codling moth (Lepidoptera: Olethreutidae) and fruittree leafroller (Lepidoptera: Tortricidae) to synthetic sex attractants. *J. Entomol. Soc. B.C.* 70:5-8.
- McMullen, R. D. 1973. The occurrence and control of the Bruce spanworm in the Okanagan Valley, 1972. *J. Entomol. Soc. B.C.* 70:8-10.
- Meheriuk, M., and Fisher, D. V. 1973. Effects of fruit position on some morphological and physiological features in spur-type Delicious apples. *Can. J. Plant Sci.* 53:589.
- Meheriuk, M., Fisher, D. V., and Lapins, K. O. 1973. Some morphological and physiological features of several Red Delicious apple sports. *Can. J. Plant Sci.* 53:335-339.
- Meheriuk, M., and Porritt, S. W. 1973. Effect of picking date, delayed storage, storage temperature, and storage atmosphere on the quality of Starking Delicious apples. *Can. J. Plant Sci.* 53:593-597.
- Miltimore, J. E., Mason, J. L., McArthur, J. M., Strachan, C. C., and Clapp, J. B. 1973. Response from copper and selenium with vitamin E injections to cattle pastured on mineral and organic groundwater soils. *Can. J. Anim. Sci.* 53:237-244.
- Morgan, C. V. G., Procter, P. J., and Vielvoye, J. 1973. Occurrence of and attempts to eradicate the grape phylloxera (Homoptera: Phylloxeridae) in British Columbia. *J. Entomol. Soc. B.C.* 70:11-12.
- Porritt, S. W., and Meheriuk, M. 1973. Influence of storage humidity and temperature on breakdown in Spartan apple. *Can. J. Plant Sci.* 53:597-599.
- Proverbs, M. D., Logan, D. M., and Carty, B. E. 1973. Some biological observations related to codling moth control by the sterility principle. Pages 149-163 in *Computer models and application of the sterile male technique*. IAEA, Vienna.
- Robinson, A. S. 1973. Increase in fertility, with repeated mating, of gamma irradiated male codling moths, *Laspeyresia pomonella* (L.) (Lepidoptera: Olethreutidae). *Can. J. Zool.* 51:427-430.
- Robinson, A. S., and Proverbs, M. D. 1973. Hybridization between geographical races of the codling moth (Lepidoptera: Olethreutidae). *Can. Entomol.* 105:289-290.
- Sneh, B. 1972. Use of cellulase and hemicellulase for the separation of *Phytophthora cactorum* oospores from mycelium mats. *Can. J. Bot.* 50:2685-2686.
- Welsh, M. F., and May, J. 1973. Suppression of the symptoms of apple leaf pucker disease in an occurrence pattern that indicates virus interaction. *Can. J. Plant Sci.* 53:137-145.
- Welsh, M. F., and May, J. 1973. Suppression of the symptoms of Stayman apple blotch apparently by virus interaction. *Can. J. Plant Sci.* 53:565-570.
- Welsh, M. F., and May, J. 1973. Temperature effects on symptom expression of apple leaf pucker disease. *Plant Dis. Rep.* 57:358-359.
- Welsh, M. F., Stace-Smith, R., and Brennan, E. 1973. Clover yellow mosaic virus from apple trees with leaf pucker disease. *Phytopathology* 63:50-57.

Miscellaneous

- Bowen, J. F. 1973. Canadian wines are naturally aged. *Canadex* 231.71.
- Bowen, J. F. 1973. Sprinkler irrigation using cannery waste water. *Agric. Inst. Can. Annu. Conv., Victoria, B.C. Mimeogr.* 5 pp.
- Bowen, J. F., and Denby, L. G. 1973. Grape and wine research at Summerland. *B.C. Orchardist* 13(8):14.
- Denby, L. G. 1973. Injury to Okanagan grapes in the winter of 1972-73. *B.C. Orchardist* 13(10):16-18.

- Fisher, D. V. 1973. Grape varieties. B.C. Orchardist 13(9):13.
- Hansen, A. J. 1973. Cherry target spot. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:81.
- Hansen, A. J. 1973. Little cherry. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:80.
- Kitson, J. A. 1973. Apple snaps—a fruit based snack food. Food Technol. in Aust. 25(7):366.
- Kitson, J. A. 1973. Apple snaps—a fruit snack food. Can. Agric. 18(4):16-17.
- Kitson, J. A. 1973. New developments in thermal processing. Pages 32-41 in B.C. Inst. Technol., Retort operators' handbook.
- Kitson, J. A. 1973. New snack food from Okanagan apples. B.C. Orchardist 13(7):16.
- Kitson, J. A. 1973. Powdered aromas for new fruit products. Sci. Affairs 7(3):19-20.
- Lapins, K. O. 1973. Spur types in McIntosh apple show promise. B.C. Orchardist 13(8):8.
- Looney, N. E. 1973. Advancing fruit harvest with Ethrel. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:65-66.
- Looney, N. E. 1973. Consumers see red (apples). Can. Agric. 18(3):32-33.
- Madsen, H. F. 1973. Synthesized lures boon in codling moth control. Ctry. Life B.C. 59(1):31.
- Madsen, H. F. 1973. What you always wanted to know about codling moth sex traps but were afraid to ask. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:93-95.
- Mason, J. L. 1973. Nutritional disorders, Spartan breakdown, bitter pit. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:29-30.
- Mason, J. L., Porritt, S. W., and Lidster, P. D. 1973. What can you do about Spartan breakdown? B.C. Orchardist 13(8):9-10.
- McArthur, J. M. 1973. Some differences between bloating and nonbloating legume forages. Can. Agric. 18(3):17-18.
- McIntosh, D. L., and Rosher, R. M. 1973. Crown rot of apple trees. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:82-83.
- McMullen, R. D. 1973. Notes on some secondary insect pests of fruit trees. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:84-87.
- Morgan, C. V. G., and Vielvoye, J. 1973. Progress report on the grape phylloxera in British Columbia. B.C. Orchardist 13(2):22-23.
- Parchomchuk, P., and McMechan, A. D. 1973. New binfillers for fruit harvesting machinery. Can. Agric. 18(3):15-16.
- Porritt, S. W. 1973. Bruising causes storage defects in sweet cherries. B.C. Orchardist 13(8):11.
- Proverbs, M. D. 1973. Current status and outlook for codling moth control by the sterility procedure. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:96-97.
- Stevenson, D. S. 1972. Trickle irrigation design principles. Wash. State Hortic. Assoc. 68th Annu. Meet. Proc. pp. 47-51.
- Stevenson, D. S. 1973. Guide to design and operation of trickle irrigation systems. Agric. Can. Res. Stn. Summerland, B.C. Inf. Bull. 23 pp.
- Stevenson, D. S. 1973. Irrigation of high density orchards. B.C. Orchardist 13(2):16-17.
- Stevenson, D. S. 1973. Irrigation systems change at the Summerland Research Station. B.C. Orchardist 13(8):13.
- Stevenson, D. S. 1973. Some principles of trickle irrigation design and some operational results. Proc. 4th B.C. Fruit Grow. Assoc. Hortic. Forum 1972:101-106.
- Stevenson, D. S. 1973. Trickle irrigation. Canadex 560.
- Stevenson, D. S. 1973. Uniform water distribution is the goal of trickle irrigation system design. Good Fruitgrower 23:9-10.

Research Station

Vancouver, British Columbia

PROFESSIONAL STAFF

M. WEINTRAUB, B.A., Ph.D., F.N.Y.A.S. Director

Scientific Support

H. M. CABALLERO (Mrs.), B.A., B.L.S. Library Coordinator, Pacific Area
T. MATSUMOTO, B.S.A., M.Sc., M.L.S. Librarian

Entomology Section

H. R. MACCARTHY, B.A., Ph.D.	Head of Section; Virus vectors
W. T. CRAM, B.S.A., M.S., Ph.D.	Strawberry insects; ecology
D. G. FINLAYSON, B.A., M.A., Ph.D.	Root maggots; toxicology
A. R. FORBES, B.A., M.S., Ph.D.	Aphids; morphology
B. D. FRAZER, B.Sc., Ph.D.	Aphid ecology
J. RAINE, B.S.A., M.S.	Berry insects; leafhopper vectors
A. T. S. WILKINSON, B.S.A.	Soil insects
I. H. WILLIAMS, ¹ B.A., M.S.	Pesticide chemistry
P. ZUK, B.A.	Stored-product insects

Pedology Section

L. FARSTAD, ² B.S.A., M.S.A.	Head of Section; Soil classification and soil correlation
A. J. GREEN, B.S.A., M.Sc.	Soil survey party leader
T. M. LORD, B.S.A.	Soil survey party leader
J. I. SNEDDON, B.S.A., M.Sc., Ph.D.	Soil survey party leader
K. W. G. VALENTINE, ³ B.A., M.A., M.Sc., Ph.D.	Soil survey party leader

Plant Pathology Section

N. S. WRIGHT, B.S.A., M.S.A., Ph.D.	Head of Section; Potato diseases; serology
H. A. DAUBENY, B.S.A., M.S.A., Ph.D.	Plant breeding, small fruits
F. D. MCELROY, B.S., Ph.D.	Nematology

F. C. MELLOR (Miss), B.S.A.
H. S. PEPIN, B.S.A., M.A., Ph.D.
R. STACE-SMITH, B.S.A., Ph.D.

Strawberry viruses; thermotherapy
Root rots; red stele of strawberry
Raspberry viruses; virus
characterization

Virus Chemistry and Physiology

H. W. J. RAGETLI, Ir., Ph.D.
R. I. HAMILTON, B.Sc., M.Sc., Ph.D.
G. G. JACOLI, B.A., Ph.D.
J. H. TREMAINE, B.Sc., M.Sc., Ph.D.

Head of Section; Chemistry and
ultrastructural cytopathology of
viruses
Virology; virus interactions and
seed transmission
Biochemical virology
Biophysical virology

Departures

J. D. ANASTASIOU (Mrs.), B.A., M.A., B.L.S.
Resigned
L. LESKIW, B.Sc., M.Sc.
Accepted position with CIDA, in Nigeria
R. N. MACK, B.S.A.
Transferred to Department of Indian and
Northern Affairs
H. N. W. TOMS, B.A.
Retired June 29, 1973

Librarian
Soil survey party leader
Administrative Services
Officer
Mycology; potato diseases

VISITING SCIENTISTS

National Research Council postdoctorate fellows

A. A. BRUNT, B.Sc., M.I. Biol., 1972-73	Plant virology
J. A. FROWD, B.Sc., M.Sc., Ph.D., 1972-73	Plant virology
T. J. MORRIS, B.Sc., M.Sc., Ph.D., 1973-74	Plant virology

Postgraduate students

G. A. DODDS, B.Sc., M.Sc.	Plant virology
D. H. PEKKALA, B.Sc., B.Ed.	Plant virology
A. F. YANG, B.Sc.	Plant virology

¹On transfer of work at Rothamsted Experimental Station, England.

²Seconded temporarily to CIDA, in Nigeria.

³Returned from educational leave, University of Reading, Reading, England.

INTRODUCTION

This is the 11th report from the Research Station, Vancouver, in which some of the main research findings over the past year are briefly described. This Station is the national center for research on plant viruses, has regional responsibility for problems in plant pathology and entomology, and coordinates soil surveys for the province.

We are pleased to welcome two new research scientists to our staff: Dr. R. I. Hamilton, who left McGill University to join us and carry on research in mixed viral infections; and Dr. H. A. Daubeney, whose arrival from Agassiz marks the consolidation of the small fruit breeding program for British Columbia at the Station. We congratulate J. I. Sneddon and K. W. G. Valentine, who have successfully completed their requirements for Ph.D. at the University of British Columbia, Vancouver, and the University of Reading, Reading, England.

Requests for further details on any phase of the program or for reprints may be directed to individual scientists or addressed to: Research Station, Research Branch, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Physical and chemical properties of viruses in vitro. Tomato aspermy virus (TAV) isolated from locally grown tomatoes was compared with a TAV isolate from chrysanthemum (CV-L) and with a cucumber mosaic virus (CMV) isolate. TAV had a sedimentation coefficient of 98 S, a diffusion coefficient of 1.49×10^{-7} cm²/sec, and a molecular weight of 5.3×10^6 . The molecular weight of the viral protein subunit was 26,300. The amino acid composition of TAV was similar to that of CV-L, showing only 4 amino acid exchanges, compared with 18 exchanges between TAV and CMV. The RNA content of TAV was 17.7%, and the base composition was Guo = 23.1%, Ado = 26.2%, Cyd = 21.6%, and Urd = 29.0%.

Five cherry leaf roll virus (CLRV) strains were compared. Each of these consisted of three components with sedimentation coefficients of 52, 114, and 132 S. Each strain produced two serologically distinct electrophoretic components, which in agar (pH 6.5) moved either to the anode (dogwood and elm strains) or to the cathode (rhubarb, golden elderberry, and cherry strains). The molecular weight of the protein subunits of the complete virions of all strains was 55,000. The lysine content of the dogwood, elm, and golden elderberry strains was significantly lower than that of the rhubarb and cherry

strains. Two RNA components with molecular weights of 2.1×10^6 and 2.3×10^6 were obtained from the golden elderberry strain. The base compositions of the middle and bottom RNA components of this strain were Guo = 26.61 and 26.55%, Ado = 21.41 and 22.01%, Cyd = 22.76 and 22.32%, and Urd = 29.22 and 29.12%. Only the middle and bottom components of these strains were infectious.

Virus infection. Following mechanical inoculation, early virus-host interactions leading to establishment in the test plant were found not to require the mediation of water. Dry, powdered inocula were prepared by grinding virus-diseased leaves in liquid nitrogen and freeze-drying the finely divided tissue. This material produced high rates of infection in test plants with the use of less than 0.6 mg of inoculum per leaf. With some of the 12 test species, belonging to 7 plant families, dry inoculation was even more effective than sap inoculation, irrespective of the presence or absence of virus inhibitors in the inoculum. Because inhibition of virus establishment was also found not to require water, the effectiveness of dry inoculation with inhibitors present in the powders seems to depend on the spatial separation of virions and inhibitors in the inoculum. The effectiveness of dry inoculation appears to depend on host characteristics, as well as on the properties of the viruses. Isometric virions and those approaching isometry may be

more effective in dry inoculation than elongated ones.

A model for inhibitor action and early virus-host interactions was proposed, based on established molecular characteristics of the virus inhibitor from carnation, *Dianthus caryophyllus* L. The characteristics are its net positive charge in the pH range in which virions are stable, its active ϵ -amino group of lysine, and the finding that polyanionic compounds such as polyaspartic acid reinforce suboptimal concentrations of the carnation inhibitor. It was suggested that initially the inhibitor combined with anionic cell receptor sites and, subsequently, aided by its particular conformation, with cationic sites located nearby. The coupled occurrence of both types of receptor sites is supported by evidence that the sensitivity of certain plant species varies in the same sense for cationic inhibitors of virus establishment and polyanionic competitive virus inhibitors.

The inhibition of ribonuclease (RNase) activity toward high molecular RNA by bentonite and RNase adsorption on bentonite were investigated by enzyme and X-ray diffraction analysis. Inhibition of the enzyme activity usually followed the pattern of expansion of the d(001) spacing of bentonite, but failed when its interlayers expanded beyond their maximum capability.

The route whereby viruses move from their site of initial entry to neighboring cells, and then to more distant cells, is important, because it is usually only when plant viruses move sufficiently to cause a systemic infection that a disease becomes economically important. One obvious route for intercellular movement would be plasmodesmata. A close study of mesophyll and phloem leaf cells infected with potato virus Y (PVY) and tobacco etch virus (TEV) revealed the presence of elongated particles in transverse and oblique sections of plasmodesmata or mesophyll, and between sieve elements and vascular parenchyma, although less frequently with TEV than with PVY. After rigorous comparison with P-protein and with the lamellar inclusions induced by these viruses, it was concluded that the plasmodesmatal particles must be virus nucleoprotein. The particles of PVY were 12–14 nm wide, with a central electron lucent core about 3 nm in diam surrounded by an electron dense inner ring, presumably of RNA, and an outer halo, probably the protein moiety. Because the

central core (or desmotubule) of the plasmodesmata and the attached endoplasmic reticulum appeared to be in place, the serious question arises as to how these long, flexuous particles can enter and traverse such a restricted pore. Further study on other elongated viruses is being done, to determine whether particles of plasmodesmatal virus are restricted to those that form lamellar inclusion bodies.

Virus multiplication. Extracts from plants of barley, *Hordeum vulgare* L., doubly infected with barley stripe mosaic virus (BSMV) and tobacco mosaic virus (TMV) were treated with TMV antibody for removal of TMV. The remaining BSMV antigen retained TMV infectivity, which was, however, neutralized by BSMV antibody, but not by TMV antibody, thereby indicating the presence of TMV-RNA, encapsulated in BSMV protein. Such genomic masking of TMV-RNA was confirmed with the use of BSMV antigen-antibody precipitates collected from sap of doubly infected plants. These precipitates contained both BSMV-RNA and TMV-RNA, but only BSMV protein. A control experiment indicated that TMV protein would also have been detected had the TMV-RNA come from normal TMV particles. As much as 8% of the RNA within BSMV antigen particles was TMV-RNA. The highest levels of genomic masking were found in doubly infected leaves maintaining the highest level of normal TMV synthesis. Isolates derived from genomically masked TMV-RNA were indistinguishable from normal TMV. No genomic masking of BSMV-RNA by TMV protein was detected.

Aster yellows disease. Electron microscopic observation showed the occurrence of unusual structures in the phloem of carrot-root and aster-stem tissue cultures infected with the aster yellows disease. The first structures to appear in the growing callus were spherical bodies of 400–1,000 nm. The bodies were surrounded by a double membrane and contained smaller vesicles ca 100 nm in diam. As the tissues aged, the bodies lost their distinct outlines, became enlarged, and their membranes gave rise to layered structures that enclosed round, viruslike particles ca 25 nm in diam. Intra- and extra-nuclear inclusions were also seen. These structures were not found in the phloem of healthy tissue cultures.

PLANT PATHOLOGY

Potatoes

Virus-free program. The eradication of virus from 19 potato accessions in 1973 brought to 128 the number of virus-free clones developed since 1966. In field plots, 110 clones of 91 cultivars and seedlings are being retained by propagation. Seed stock from the program was sent on request to Elite seed farms and research institutions in eight provinces of Canada and to the USA, Cuba, and Mexico.

Experiments on late season reinfection of the Netted Gem cultivar with potato virus X (PVX) showed that the extent of tuber infection increased with time between inoculation and defoliation but was unrelated to tuber size.

Approximately 81 ha (200 ac) of virus-tested seed potatoes were grown in British Columbia in 1973. No virus was found in any of 26 plots of Elite 1. Eighteen of 22 plots of Elite 2 were also virus-free; 2 contained a trace of PVX and 2 others a trace of potato virus S. Zero readings for PVX were obtained in 20 fields of Elite 3, but 3 others contained 2.8 (± 1.6), 22.0 (± 4.8), and 22.8 (± 3.8) % infected plants. One Foundation field was given a zero reading for PVX, but four others contained 1.8 (± 1.0), 5.0 (± 1.8), 18.3 (± 3.4), and 44.9 (± 4.5) % infected plants.

Virology

Tobacco ringspot virus. A sweet cherry tree in the Okanagan Valley was found with leaves showing a light green zonal discoloration. The symptoms were present during 3 yr of observation. A virus was sap-transmitted from the cherry tree to cucumber, *Chenopodium quinoa* Willd., and *Nicotiana clevelandii* A. Gray. An infected blackberry plant showing leaf enations was found near Kamloops. A virus was again sap-transmitted to herbaceous hosts whose symptoms indicated that a single virus was present. Viruses from both sources were purified from *N. clevelandii* and used to produce antisera; serological tests identified both viruses as tobacco ringspot virus. This virus has not been found previously in British Columbia. Both isolates were serologically identical and indistinguishable from a tobacco isolate originating in Ontario. The vector, *Xiphinema americanum* Cobb, was present in the

soil at both locations, but there was no evidence of field spread.

Small Fruits

Control of mummy berry of highbush blueberry. Plots of cv. Weymouth with a relatively uniform inoculum level of *Monilinia vaccinii-corymbosi* (Reade) Honey were treated during March, April, and May with split-schedule spray applications of benomyl at 1.12 and 0.56 kg active ingredient/ha; Baydam 18654 (Chemagro, Division of Baychem Corp.) at 0.56 and 1.12 kg; Daconil (Diamond Shamrock Chemical Co.) at 1.68 kg; captafol at 1.40 kg; ferbam at 2.52 kg; thiophanate-methyl at 0.56 kg; thiophamine (NF 48; Nippon Soda Co.) at 0.56 kg; triforine (Cela W524; Celamerck GBMH and Co.) at 0.28 kg and 0.56 kg; and triforine at 0.28 kg plus benomyl at 0.56 kg.

Weather during the spring of 1973 was favorable for ascospore infection but a prolonged dry spell during the conidial infection period resulted in a low incidence of mummies. Yields were about double those of 1972.

Triforine was superior to all other fungicides tested as a protectant against ascospore infection and was equal to benomyl for control of secondary infections. Benomyl, triforine, Baydam 18654, thiophanate-methyl, and thiophamine significantly reduced conidial infections. Baydam 18654, thiophanate-methyl, and triforine significantly increased yields.

Nematodes

Chemical control in raspberry. DBCP (Nemagon; Shell Canada Ltd.) injected into the soil around 3-yr-old raspberries reduced populations of *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. both in the roots and the soil, and of *Xiphinema bakeri* Williams in the soil. Rates of 22.5 and 33.8 litres/ha (2 and 3 gal/ac) increased plant growth and yield the first 2 yr after treatment. Higher rates were phytotoxic and caused decreases in growth and yield.

Vydate (DuPont of Canada Ltd.) applied as a spring foliar spray also gave good control of nematodes with up to 30% increase in yield. Total yield increases for the 2 yr after treatment at 0.5, 1.0, and 2.0 g/100 litres were 2.7, 1.8, and 4.0 t/ha (1.2, 0.8, and 1.8 tons/ac). Vydate applied at the same rates in the greenhouse reduced nematode

soil populations by 86%, 97%, and 99% and root populations by 96%, 99%, and 99%, and increased plant growth by 25%, 21%, and 37%. Other tests indicated that four sprays are necessary for optimum nematode control and plant growth.

Chemical control in loganberry. Vydate applied to 9-yr-old declining loganberries gave good control of nematodes and leafhoppers. It also reduced dry berry disease by 40–50%. Rates of 0.5, 1.0, and 2.0 g/100 litres increased the yield over the untreated control by 4.0, 4.0, and 2.0 t/ha (1.8, 1.8, and 0.9 tons/ac). An azinphos-methyl insecticide control was only slightly better than the untreated control.

ENTOMOLOGY

Vectors

Microorganism-like bodies. Several kinds of microorganism-like bodies were observed in type III acini of the salivary glands of the aster leafhopper, *Macrosteles fascifrons* (Stål). These included two types of Rickettsia-like bodies, mycoplasma-like bodies (MLB's), and some compressed pleomorphic bodies in sacs, which often separated and differentiated near the periphery of the sac into bodies with uniformly granular interiors bounded by a unit membrane. They resembled bodies previously reported in the glands and saliva of healthy insects and in newly emerged nymphs. The bodies in the sacs were digested by pronase and pepsin, and partly by trypsin. Digestions with ribonuclease and deoxyribonuclease were inconclusive.

When the salivary glands of individually preestablished transmitting leafhoppers were examined, characteristic MLB's as seen in diseased plants were found only in the transmitters but not in the nontransmitters.

Morphology and fine structure. The innervation of the stylets and labium of the spotted alfalfa aphid, *Therioaphis maculata* (Buckton), and of the lupine aphid, *Macrosiphum albifrons* Essig, were examined to complete a series of 13 studies. Both aphids have two dendrites in a central duct of each mandibular stylet. Each dendrite consists of a cell membrane and two neurotubules embedded in a structureless matrix. Sections near the tip of the labium showed 8 pairs of nerves innervating 16 conical setae, which apparently are involved in mechano- or

chemo-reception, or both. Other mouthparts studied were those of the hemlock chermes, *Adelges tsugae* Annand, and the onion thrips, *Thrips tabaci* Lindeman.

Aphid species. A taxonomic list was published comprising 213 species of aphids, collected from 255 host plants. The host list of more than 100 new host plants was also cataloged and published. Fifty-three species of aphids have been identified since the original list was closed.

Aphid ecology. Populations of the pea aphid, *Acyrtosiphon pisum* (Harris), and its predators, parasites, and pathogens were monitored in alfalfa fields. The field measurements permitted the transformation of an already established predation model, derived from analyses of laboratory data on behavior of and predation by the ladybird beetle, *Coccinella undecimpunctata* L., into one that could be used in the field for all species of ladybird beetles present. The aim is a predictive model of the population dynamics of the pea aphid.

Strawberry Pests

Root weevils. In the second cropping season of barriered microplots, each enclosing five cultivars and one of four species of nonflying weevils at either low or high levels, there were significant differences in yield among cultivars in the plot with the high level of *Otiorhynchus sulcatus* F. The yield from Totem was not significantly greater than that from Cheam, but it was significantly greater than that from BC-25, Shuksan, and Northwest. Totem was the only cultivar in this plot that did not produce a significantly lower yield than its control in the uninfested plot. The average yield for all cultivars in this plot having a high level of *O. sulcatus* was only 337 g/plant, whereas it was 753 g in the uninfested plot, where all the cultivars had similar yields. In the laboratory, adults of *O. sulcatus* that were fed exclusively on foliage of Totem laid about half as many viable eggs as those fed on other cultivars.

Strawberry tortrix. This newly introduced European pest, *Acleris comariana* (Zeller), was studied in the field. Its distribution was still closely restricted to the area of its discovery. Chemical control trials of nine insecticides showed that five of these were effective at the prebloom stage against larvae in the third instar or earlier. Overwintering

eggs were found on hardhack, a common, native shrublike weed. Larval parasites were rare in the first generation but common in the second. Late in the season, a large population of moths emerged from which mostly males were taken in a modified light trap.

Wireworms

Chemical control. Five experimental and registered insecticides were bioassayed at various rates in the laboratory with larvae of the European wireworm, *Agriotes obscurus* L. The most effective insecticide killed all the larvae within 15 days, the second two within 30 days, the third within 47 days, and the last failed to reduce the numbers adequately. The four best of these materials, together with a new experimental compound, were tested against the same pest in a potato field in various formulations and methods of application. Three of the insecticides reduced the number of unmarketable tubers in potatoes to about 3%.

According to the cooperative association that markets most of the potatoes in the Fraser Valley, wireworm damage in potatoes increased in 1972 and 1973. An examination of several fields showed that *Agriotes sparsus* LeConte and *Ctenicera lobata* (Esch.) were the species mainly responsible. The European wireworm was discovered on Barnston Island in the Fraser River near Cloverdale. This is a 30-mile extension in distribution.

Leatherjackets

Biological control. Populations of the European crane fly, *Tipula paludosa* Meigen, in untreated grassland declined considerably in 1973, as an effect of indigenous and imported agents. Rearing leatherjackets in the laboratory has become extremely difficult. At Cloverdale, parasitism by the tachinid fly, *Siphona geniculata* DeGeer, rose above 6% during the summer. At the Research Station, the population fell from a high of 1,604/m² in winter to 400/m² in April; at Cloverdale it fell from 165/m² in January to 50/m² in June.

Nearly all the leatherjackets including those found in Washington State and in the newly discovered outbreak on Vancouver Island were infected with coelomic gregarines. Many were massive infections. The most common gregarine encountered was identified in England as *Diplocystis* sp. To

increase the local gene pool, two releases were made of 315 and 68 parasitized leatherjackets from Switzerland. Adult *Siphona* flies and parasitized leatherjackets were sent to Newfoundland and released.

Root Maggots

Compatibility. Three herbicides and four insecticides were applied by various methods and combinations to soil in which mini-curd cauliflowers were seeded directly in six-row beds. None of the compounds alone or combined reduced emergence, but the herbicide trifluralin reduced the efficacy of the insecticides against root maggots. The numbers of predatory beetles, aphids, cabbage worms, and larvae of the diamondback moth and looper were unaffected at harvest, except for some reduction where the insecticide carbofuran was used.

In a similar experiment with direct-seeded broccoli, cabbage, cauliflower, and rutabaga, 11 herbicides were used as preseeding, preemergence, or postemergence treatments, and two insecticides; the results were also similar. In both experiments, control of the *Hylemya* root maggots was good, but the population in the untreated plots was high and the damage very severe.

Residue Chemistry

Organophosphorus residues. The method developed for analysis of diazinon residues in carrots was successfully modified for use in cranberries treated for control of the cranberry girdler, *Chrysoteuchia topiaria* (Zeller). A method was developed for ethion residues, which used sweep codistillation for the preliminary cleanup. The residues were markedly concentrated in the top 3 cm of the carrot, whereas the lowest 8 cm of the root contained almost no residue. The peel had residues about ten times greater than those in the pulp.

Carbamate residues. A method of determining residues of carbofuran and its 3-hydroxy metabolite in small fruits was worked out, tested, and published. The method was extended later to soil, cauliflower curds and foliage, potatoes, forage, and carrots. Satisfactory recoveries were made. In cranberries treated for control of the blackheaded fireworm, *Rhopobota naevana* (Hübner), no residues were detected where carbofuran was applied at 3.4 kg/ha, but this rate may be too low. In carrots, the

distribution of residue in the root was similar to that of ethion.

PEDOLOGY

Classification and Mapping

A reconnaissance soil survey of about 1,100,000 ha was completed in mountainous and plateau areas northwest of Prince George. Soils and landforms were mapped, and forest productivity was measured by means of road traverses and helicopter drops.

Soil resource and land use surveys of 12 Indian reserves in British Columbia were completed and published. Soil management areas were described and suitable crops, irrigation requirements, and fertilizer use were determined for 4,000 ha.

Soil mapping units covering the Capital Regional District of Victoria were interpreted for regional planners. Soil capabilities for agriculture maps were assessed for delineation of agricultural reserves throughout the province.

Soil Characterization

A study of the soils, their physical and chemical characteristics, and their relationship to vegetation was completed as part of the Chilliwack Provincial Forest Integrated Resource Study. The objective of this study, initiated by the Research Division, B.C. Forest Service, is to develop a multiuse plan for the Chilliwack Forest and to study mapping techniques, data collection, and interpretations for future resource management.

PUBLICATIONS

Research

Cram, W. T. 1973. Occurrence of the strawberry tortrix, *Acleris comariana* (Zeller), a new pest in British Columbia (Lepidoptera: Tortricidae). J. Entomol. Soc. B.C. 70:17.

Daubeney, H. A., and Pepin, H. S. 1973. Variations in fruit rot susceptibility of strawberry cultivars and selections as indicated by a postharvest screening technique. Can. J. Plant Sci. 53:341-343.

Finlayson, D. G., and MacCarthy, H. R. 1973. Pesticide residues in plants. Pages 57-86 in C. A. Edwards, ed. Environmental pollution by pesticides. Plenum Press, London.

Forbes, A. R., and Frazer, B. D. 1973. The aphids (Homoptera: Aphididae) of British Columbia. 2. A host plant catalogue. J. Entomol. Soc. B.C. 70:58-68.

Forbes, A. R., Frazer, B. D., and MacCarthy, H. R. 1973. The aphids (Homoptera: Aphididae) of British Columbia. 1. A basic taxonomic list. J. Entomol. Soc. B.C. 70:43-57.

Forbes, A. R., and Raine, J. 1973. The stylets of the six-spotted leafhopper, *Macrostelus fascifrons* (Homoptera: Cicadellae). Can. Entomol. 105:559-567.

Frazer, B. D., and van den Bosch, R. 1973. Biological control of the walnut aphid in California: the interrelationship of the aphid and its parasite. Environ. Entomol. 2:561-568.

Jacoli, G. G., Ronald, W. P., and Lavkulich, L. 1973. Inhibition of ribonuclease activity by bentonite. Can. J. Biochem. 51:1558-1565.

McElroy, F. D. 1973. Control of *Pratylenchus penetrans* in raspberry root cuttings. Plant Dis. Rep. 57:492-495.

Ragetli, H. W. J., Weintraub, M., and Elder, M. 1973. Effective mechanical inoculation of plant viruses in the absence of water. Can. J. Bot. 51:1977-1982.

Stace-Smith, R., and Lo, E. 1973. Morphology of bacilliform particles associated with raspberry vein chlorosis virus. Can. J. Bot. 51:1343-1345.

Stace-Smith, R., and Tremaine, J. H. 1973. Biophysical and biochemical properties of tomato aspermy virus. Virology 51:401-408.

Walkey, D. G. A., Stace-Smith, R., and Tremaine, J. H. 1973. Serological, physical and chemical properties of strains of cherry leaf roll virus. Phytopathology 63:566-571.

Weintraub, M., Agrawal, H. O., and Ragetli, H. W. J. 1973. Cytoplasmic and nuclear inclusions in leaf cells infected with *Datura* shoe-string virus (DSV). Can. J. Bot. 51:855-861.

Welsh, M. F., Stace-Smith, R., and Brennan, E. 1973. Clover yellow mosaic virus from apple trees with leaf pucker disease. Phytopathology 63:50-57.

- Williams, I. H. 1973. Photochemical oxidation of hexane isomers to compounds sensitive to electron capture detection. *J. Chromatogr. Sci.* 11:593-596.
- Williams, I. H., and Brown, M. J. 1973. Determination of carbofuran and 3-hydroxycarbofuran residues in small fruits. *J. Agric. Food Chem.* 21:399-401.
- Williams, I. H., Brown, M. J., and Finlayson, D. G. 1972. Determination of residues of fensulfothion and its sulfone in muck soil. *J. Agric. Food Chem.* 20:1219-1221.
- ### Miscellaneous
- Basu, P. K., Crête, R., Donaldson, A. G., Gourley, C. O., Haas, J. H., Harper, F. R., Lawrence, C. H., Seaman, W. L., Toms, H. N. W., Wong, S. I., and Zimmer, R. C. 1973. Prevalence and severity of diseases of processing peas in Canada, 1970-71. *Can. Plant Dis. Surv.* 53:49-57.
- Bedwany, A. L., and Sneddon, J. I. 1973. Selected references on interpretation of soils information. Rep. Natl. Soil Surv. Comm. May 1973. Mimeogr.
- Brown, C. H., Dawson, A. B., Luttmerding, H. A., van Ryswyk, A. L., and Sneddon, J. I. 1973. Capability classification of organic soils for agriculture. Appendix I in *Methodology for agriculture. B.C. Land Inventory (CLI)*, by G. G. Runka. B.C. Dep. Agric., Kelowna, B.C.
- Cram, W. T. 1973. The strawberry tortrix—a new pest in British Columbia. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:20-23. Abbotsford, B.C.
- Farstad, L., and Sneddon, J. I. 1972. Report on Podzolic tour of western Canada. Oct. 1-3, 1971. Rep. Natl. Soil Surv. Comm. Mimeogr.
- Green, A. J., Watt, W. J., and Lord, T. M. 1973. Soils of the Prince George Forest District, eastern section. Course outline: geology, landforms and soils of the Peace River Area. Fort St. John, Oct. 1-3, 1973. Queen's Printer, Vancouver, B.C.
- Leskiw, L. A., and Farstad, L. 1973. A soil resource and land use survey of the Canim Lake Indian Reserve. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Leskiw, L. A., Farstad, L., and Bedwany, A. L. 1973. A soil resource and land use survey of the Toosey Indian Reserve. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Leskiw, L. A., Farstad, L., and Bedwany, A. L. 1973. A soil resource and land use survey of the Alkali Lake Indian Reserve. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Leskiw, L. A., Farstad, L., and Lord, T. M. 1973. A soil resource and land use survey of the Williams Lake Indian Reserve. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Leskiw, L. A., Farstad, L., and Sneddon, J. I. 1973. A soil resource and land use survey of the Anahim Indian Reserve. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Leskiw, L. A., Farstad, L., and Sneddon, J. I. 1973. A soil resource and land use survey of the Redstone Indian Reserve. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Leskiw, L. A., Farstad, L., and Watt, W. J. 1973. A soil resource and land use survey of the Stoney Indian Reserve. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- McElroy, F. D. 1973. Elimination of nematodes from raspberry root cuttings. *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:59-60. Abbotsford, B.C.
- McElroy, F. D. 1973. What's new in nematode control? *Proc. Lower Mainland Hortic. Improv. Assoc.* 15:58-59. Abbotsford, B.C.
- Ragetli, H. W. J., and Weintraub, M. 1973. The influence of inhibitors on the reaction of the indicator plants. Invitation paper, No. 0094, 2nd Int. Congr. Plant Pathol., Minnesota. Sept. 5-12, 1973.
- Watt, W. J., and Farstad, L. 1973. A soil resource and land use survey of the Halfway River Indian Reserve No. 168. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Wiken, E. B., and Farstad, L. 1973. A soil resource and land use survey of the East Moberly Lake Indian Reserve No. 168A. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Wiken, E. B., and Farstad, L. 1973. A soil resource and land use survey of the West Moberly Lake Indian Reserve No. 169. R. E. Carlyle, ed. Queen's Printer, Vancouver, B.C.
- Wright, N. S. 1973. Potato disease research projects in Canada and United States in 1972. *Am. Potato J.* 50:168-179.

[illegible]

INDEX OF PROFESSIONAL STAFF AND VISITING SCIENTISTS

- Aalders, L. E., 17
 Acton, C. J., 172
 Acton, D. F., 172
 Adams, (Mrs.) J. B., 31
 Adamson, R. M., 325
 Ainsworth, L., 118
 Aitken, J. R., 118, viii
 Ali-Khan, S. T., 215
 Allan, J. R., 294
 Allen, H. T., 285
 Allen, W. R., 109
 Allen, W. R., 224
 Allyson, (Miss) S. A., 131
 Anastasiou, J. D., 342
 Anderson, C. H., 265
 Anderson, D. T., 294
 Anderson, J. R., 295
 Anderson, J. S., 199
 Anderson, L. J., 81
 Anderson, R. V., 129
 Andison, H., 325
 Andrews, C. J., 148
 Andrews, J. E., 293
 Anstey, T. H., v
 Armstrong, K. C., 93
 Arnason, S. B., 293
 Arnold, J. W., 130
 Arnold, (Mrs.) R., 131
 Arthur, A. P., 252
 Atkinson, R. G., 325
 Atkinson, T. G., 294
 Atwal, A. S., 119
 Ayers, G. W., 8
 Aylesworth, J. W., 81, 82
 Ayre, G. L., 224
 Ayres, K. W., 172
 Baenziger, H., 94
 Bagnall, R. H., 31
 Baier, W., 148
 Bailey, C. B. M., 293
 Bailey, L. D., 207
 Baker, R. J., 223
 Ballantyne, A. K., 172
 Banham, F. L., 329
 Banting, J. D., 243
 Barker, P. S., 224
 Barnett, G., 54
 Barr, D. J. S., 131
 Barr, G. R., 117
 Barran, L. R., 147
 Barron, J. R., 131
 Bassett, I. J., 129
 Basu, P. K., 93
 Baum, B. R., 129
 Beacom, S. E., 235
 Becker, E. C., 130
 Bedwany, T., 173
 Behki, R. M., 147
 Beke, G. J., 172
 Belanger, A., 65
 Bell, E. F., 329
 Bellamy, R. E., 252
 Belzile, L., 54
 Bendelow, V. M., 223
 Bender, F., 162
 Berck, B., 224
 Berkenkamp, W. B., 285
 Bernard, C. S., 45
 Bernier, R., 65
 Bertoia, D. R., 325
 Berube, D. E., 244
 Best, K. R., 243
 Bickis, M. G., 205, 224
 Biederbeck, V. O., 266
 Binns, M. R., 203
 Bisal, F., 266
 Bishop, C. J., viii
 Bishop, R. F., 18
 Black, W. N., 7
 Blakeley, P. E., 293
 Blatt, C. R., 17
 Boch, R., 94
 Bodnaryk, R. P., 224
 Boivin, B., 129
 Bolduc, R., 53
 Bole, J. B., 294
 Bolton, A. T., 95, 199
 Bolton, E. F., 81
 Bond, E. J., 183
 Bonin, S. G., 277
 Bonn, W. G., 82
 Bonneau, Y., 65
 Bordeleau, L., 54
 Botten, (Mrs.) M. G., 147
 Bouchard, R., 45
 Boughton, G. R., 243
 Bourget, S. J., 53
 Bowden, D. M., 293
 Bowen, J. F., 330
 Bowes, G. G., 243
 Bowman, B. T., 183
 Bowren, K. E., 235
 Boyer, J. C., 251
 Brach, E. J., 191
 Bracken, G. K., 224
 Bradley, G. A., 132
 Bradley, J. A., 285
 Bradley, R. H. E., 31
 Bright, D. E., 130
 Britton, (Miss) D., 330
 Bronskill, (Miss) J., 148
 Brown, B. E., 183
 Brown, D., 223
 Brunt, A. A., 342
 Brydon, J. E., 173
 Buchannon, K. W., 223
 Bucher, G. E., 224
 Buckley, A. R., 199
 Buckley, D. J., 191
 Buglass, E., 244
 Bullen, M. R., 53

- Burgess, L., 252
 Burgess, P. L., 31
 Burnett, P. A., 225
 Burnett, T., 94
 Burrage, R. H., 252
 Burrows, V. D., 93
 Butler, K. P., 17
 Buttery, B. R., 81
 Buttkus, H. A., 330
 Buzzell, R. I., 81
 Byers, J. R., 130
- Caballero, (Mrs.) H. M., 341
 Cairns, R. R., 285
 Calder, F. W., 18
 Callbeck, L. C., 8
 Cameron, B. H., 172
 Cameron, D. R., 171, 203
 Campbell, A., 225
 Campbell, A. B., 223
 Campbell, C. A., 266
 Campbell, C. G., 215
 Campbell, J. M., 130
 Campbell, S. J., 251
 Carefoot, J. M., 294
 Carter, K. M., 17
 Cartier, J. J., viii
 Casserly, L. M., 94
 Castell, A. G., 235
 Chan, A., 199, viii
 Chancey, H. W. R., 1
 Chaplin, C. E., ix
 Chapman, F. M., 330
 Chapman, R. A., 183
 Charles, W. B., 278
 Charnetski, W. A., 294
 Chefurka, W., 183
 Chen, (Mrs.) F., 251
 Cheng, H. H., 75
 Cheng, K.-J., 293
 Chi, C. C., 94
 Chiang, M. S., 65
 Chiba, M., 109
 Chiko, A. W., 223
 Childers, W. R., 94
 Chinn, S. H. F., 252
 Chipman, E. W., 18
 Chisholm, D., 18
 Chiykowski, L. N., 148
 Chow, P. N. P., 207
 Christie, P., 173
 Chubb, W. O., 215
 Chubey, B. B., 215
 Church, N. S., 252
 Ciperá, J. D., 117
 Clark, D. J., 203
 Clark, J. S., 171
 Clark, M. C., 31
 Clark, R. V., 93
 Clarke, M. F., viii
 Cliplef, R. L., 207
 Coates, W. E., 235
 Cody, W. J., 129
- Coen, G. M., 173
 Collins, W. B., 31
 Comeau, A., 53
 Comeau, J. E., 54
 Cooke, D. A., 235
 Cooper, D. J., 191
 Cordukes, W. E., 199
 Corlett, M. P., 131
 Coulombe, L. J., 65
 Court, W. A., 75
 Cox, A. C., 18
 Craig, C. H., 252
 Craig, D. L., 17
 Cram, W. T., 341
 Crête, R., 65
 Croome, G. C. R., 293
 Crossley, J. H., 325
 Crosson, L. S., 173
 Crowe, A. D., 18
 Crowle, W. L., 251
 Crown, P. H., 173
 Cumming, W. A., 215
 Cutcliffe, J. A., 8
 Czarnecki, E. M., 223
- Darisse, J. P. F., 54
 Darwent, A. L., 277
 Daubeny, H. A., 313, 341
 Davidson, H. R., 149
 Davidson, J. G. N., 277
 Davidson, T. R., 109
 Davies, H. T., 31
 Davis, G. R. F., 252
 Davis, W. E. P., 313
 Dawley, W. K., 278
 Day, J. H., 171, 173
 Dedio, W., 265
 De Jong, H., 31
 De Kimpe, C., 54
 de la Roche, I., 93
 de Marquez, L. A., 295
 DePauw, R. M., 277
 Depner, K. R., 295
 Deschênes, J. M., 53
 Desjardins, R. L., 148
 Dessureaux, L., 94
 Dew, D. A., 285
 Dhanvantari, B. N., 82
 Dias, H. F., 109
 Dionne, J.-L., 45
 Doane, J. F., 252
 Dodds, G. A., 342
 Dodds, M. E., 265
 Dondale, C. D., 130
 Donovan, L. S., 94
 Doornenbal, H., 285
 Dore, W. G., 129
 Dormaar, J. F., 294
 Dorrell, D. G., 215
 Downes, J. A., 130
 Downey, R. K., 251
 Downing, C. G. E., viii, 191
 Downing, R. S., 329

- Drapeau, R., 54
 Dryden, R. D., 207
 Dubetz, S., 294
 Dubuc, J. P., 53
 Dueck, J., 82
 Dufour, J., 45
 Dumanski, J., 171
 Dumas, T., 183
 Dunkelgod, K. E., 265
 Dupré, M., 41
 Durkee, A. B., 161
 Dyck, F. B., 266
 Dyck, G. W., 207
 Dyck, P. L., 223
- Edey, S. N., 148
 Elliot, J. I., 117
 Elliot, J. M., 75
 Elliott, C. R., 277
 Elliott, J. A., 161
 Elliott, (Miss) M. E., 131
 Elliott, W. M., 81
 Ellis, R., 132
 Emmond, G. S., 243
 Emmons, D. B., 161
 Emsley, J. A. B., 117
 Enns, H., 215
 Erfle, J. D., 118
 Everett, C. F., 31
 Ewen, A. B., 252
- Fahmy, M. H., 45
 Falgon, C., 54
 Faris, D. G., 277
 Farstad, L., 173, 341
 Fedak, G., 93
 Fejer, S. O., 93
 Feldman, M., 191
 Ferguson, W. S., viii
 Findlay, W. I., 82
 Finlayson, D. G., 341
 Fisher, D. V., 329
 Fisher, J. C., 83
 Fisher, (Miss) K. H., 83
 Fisher, L. J., 118
 Fisher, R. W., 109
 Fleischmann, G., 147
 Flipot, P., 45
 Folkins, L. P., 285
 Foott, W. H., 81
 Forbes, A. R., 341
 Ford, R. J., 252
 Forest, J., 66
 Forrest, R. J., 313
 Forsyth, F. R., 18
 Foster, T. S., 118
 Frappier, J. R., 53
 Frazer, B. D., 341
 Fredeen, F. J. H., 252
 Fredeen, H. T., 285
 Freeman, J. A., 313
 Freyman, S., 294
 Friend, D. W., 118
- Friesen, H. A., 285
 Frowd, J. A., 342
 Fulton, J. M., 81
 Fung, J., 184
- Gagnon, C., 53
 Gamble, D. S., 171
 Gammon, D. B., 31
 Gardiner, E. E., 293
 Garnett, I., 207
 Gasser, H., 53
 Gates, L. F., 82
 Gaunce, A. P., 329
 Gavora, J. S., 117
 Gayed, S. K., 75
 Gaynor, J., 171
 Gazeley, (Mrs.) J. E., 119
 Généreux, H., 54
 Genest, J., 45
 Gerber, G. H., 224
 Gibson, D. R., 94
 Giesbrecht, J. E., 215
 Gill, C. C., 223
 Gillespie, J. E., 172
 Ginns, J. H., 131
 Gochnauer, T. A., 94
 Goplen, B. P., 251
 Gorrill, A. D. L., 31
 Goud, J. V., 216
 Gourley, C. O., 18
 Gowe, R. S., 117
 Graham, (Ms.) L. M. A., 203
 Granger, R. L., 65
 Grant, E. A., 31
 Grant, M. N., 294
 Green, A. J., 173, 341
 Green, D. G., 265
 Green, G. J., 223
 Greenhalgh, R., 147, 148
 Greenshields, J. E. R., 251
 Griffith, S. M., 174
 Gross, A. T. H., 207
 Grover, R., 243
 Grunder, A. A., 117
 Gubbels, G. H., 215
 Guitard, A. A., 265
 Guppy, J. C., 94
 Gupta, U. C., 7
- Haas, J. H., 82
 Hache, B. J., 203
 Hackett, A. J., 118
 Hagborg, W. A. F., 224
 Haggis, G. H., 148
 Hagley, E. A. C., 109
 Hall, I. V., 17
 Halstead, R. L., viii
 Hamill, A. S., 81
 Hamilton, D. G., v
 Hamilton, H. A., 65
 Hamilton, K. G. A., 130
 Hamilton, M. D., 277
 Hamilton, R. I., 207

Hamilton, R. I., 342
 Hamilton, R. M. G., 118
 Hampson, M. C., 1
 Hanna, M. R., 294
 Hannay, C. L., 183
 Hansen, A. J., 330
 Harcourt, D. G., 94
 Harder, D. E., 223
 Harding, H., 252
 Hardwick, D. F., 129
 Harper, A. M., 294
 Harper, F. R., 294
 Harris, C. R., 183
 Harris, P., 243
 Harris, R. E., 277
 Harwalkar, V. R., 162
 Haufe, W. O., 295
 Hawn, E. J., 294
 Hay, J. R., 243
 Hayhoe, H. N., 148, 203
 Heaney, D. P., 118
 Heapy, L. A., 286
 Heeney, H. B., 94
 Hegde, B. R., 296
 Hegdekar, B. M., 224
 Heinrichs, D. H., 265
 Helson, V. A., 93
 Hennig, A. M. F., 277
 Herbert, (Miss) H. J., 17
 Heringa, P. K., 1, 172
 Herne, D. H. C., 109
 Hickman, C. G., 117
 Hidioglou, M., 118
 Hill, A. T., 313
 Hinks, C. F., 130
 Hinman, W. C., 266
 Hironaka, R., 293
 Hobbs, E. H., 295
 Hobbs, G. A., 294
 Hodgson, W. A., 31
 Hoes, J. A., 215
 Hogue, E. J., 65
 Holland, G. P., 130
 Hollands, K. G., 117
 Holliday, W. B., 319
 Holmes, D. P., 93
 Holmes, N. D., 294
 Hope, G. W., 162
 Hope, H. J., 53
 Hopkins, J. F., 82
 Hore, F. R., 191
 Hosono, A., 162
 House, H. L., 94
 Howarth, R. E., 251, 329
 Howes, N. K., 225
 Hoyt, P. B., 277
 Huang, H.-C., 253
 Hubbard, W. A., 319
 Hudon, M., 65
 Hudson, (Miss) B. N. A., 130
 Hughes, S. J., 131
 Hulan, H. W., 118
 Humphrey, S. E., 172, 173

Hunsaker, W. G., 118
 Hunt, J. R., 118, 119, 313
 Hunter, J. H., 243
 Hurd, E. A., 265
 Hutchinson, D. A., 7
 Hutt, J. H., 191, 203

Ibrahim, E., 119
 Ihnat, M., 147
 Ivany, J. A., 8
 Ivarson, K. C., 171

Jablonski, B. W., 199
 Jackson, H. A., 191
 Jackson, L. P., 18
 Jacoli, G. G., 342
 James, W. C., 93
 Janzen, W. K., 173
 Jaques, R. P., 81
 Jasmin, J. J., 65
 Jenkins, K. J., 118
 Joanisse, J., 161
 John, M. K., 313
 Johnson, P. W., 82
 Johnston, A., 294
 Johnston, G. R., 94
 Johnston, H. W., 7
 Jones, D. R., 184
 Jones, J. D., 162
 Jordan, W. A., 118

Kalab, M., 162
 Kaldy, M. S., 294
 Kashi, K. P., 184
 Kasting, R., 294
 Kataria, D. P., 266
 Kaufmann, M. L., 285
 Kavanagh, G. P., 117
 Kayler, W. E., 82
 Keller, D. G., 296
 Keller, W. A., 93
 Kelton, L. A., 130
 Kemp, G. A., 294
 Kemp, J. G., 31
 Kemp, W. G., 109
 Kenaschuk, E. O., 215
 Kerber, E. R., 223
 Kerley, G. E., 265
 Keys, C. H., 251
 Khan, (Mrs) M., 129
 Khan, M. A., 295
 Khan, S. U., 147, 244
 Kiehn, F. A., 225
 Kilcher, M. R., 265
 Kim, W. K., 223
 Kimpinski, J., 7
 Kinsman, D. R., ix
 Kitson, J. A., 330
 Kjeersgaard, A. A., 173
 Klassen, A. J., 251
 Klein, K. K., 293
 Kloosterman, B., 171
 Knowles, R. P., 251

Kocaoglu, S. S., 173
 Kodama, H., 171
 Korven, H. C., 265
 Kovacicova, J., 148
 Kowalonko, C. G., 171
 Kozub, G. C., 293
 Kozumplik, V., 41
 Kramer, J. K. G., 118
 Kristjansson, F. K., 93
 Krogman, K. K., 295
 Krupka, R. M., 183
 Kunelius, H. T., 7

 Laflamme, L., 45
 Lafontaine, J. D., 131
 Laird, (Mrs.) A. K., 265
 Lajoie, P. G., 172
 Lalande, G., 45
 Lamarre, M., 41
 Langille, J. E., 18
 Langmaid, K. K., 172
 Lantagne, M., 31, 32
 Lapins, K. O., 330
 Lareau, M., 65
 Larmond, (Mrs.) E., 162
 Larson, (Miss) R. I., 294
 Last, K. B., 117
 Laverdière, M., 54
 Lavery, J. C., 329
 Lawetz, V., 117
 Lawrence, C. H., 32
 Lawrence, T., 265
 Lawson, J. E., 293
 Layne, R. E. C., 82
 Lebeau, J. B., 294
 Lebeau, J. V., 54
 Ledingham, R. J., 252
 Lee, C. R., 32
 Lee, D. H., 81
 Lee, T. T., 183
 Lee, Y. W., 252
 Leefe, J. S., 18
 Lefkovitch, L. P., viii, 203
 Leger, D. A., 117
 Leisle, D., 223
 Leitch, R. H., 277
 LeLacheur, K. W., 7
 Lentz, W. E., 117
 LeRoux, E. J., v, viii
 Leskiw, L. A., 173, 342
 Lesley, S. M., 147
 Lessard, J. R., 118
 Leuty, S. J., 94
 Levesque, M., 172
 Lievers, K. W., 191, 203
 Lilly, C. E., 294
 Lin, C. S., 203
 Lindquist, E. E., 130
 Lindwall, C. W., 295
 Lister, E. E., 118
 Loan, C. C., 131
 Lockhart, C. L., 18
 Lodge, G. A., 117

Lodge, R. W., 266
 Loiselle, J. G. R., 93
 Looman, J., 265
 Looney, N. E., 330
 Lopatecki, L. E., 330
 Lord, T. M., 173, 341
 Loschiavo, S. R., 224
 Lovering, J. H., 7
 Ludwig, R. A., v, ix
 Lukosevicius, P. P., 41
 Lutwick, L. E., 295
 Lyall, L. H., 93

 Maas, E. F., 313
 MacCarthy, H. R., 341
 MacDonald, M. D., 294
 MacDowall, F. D. H., 148
 MacEachern, C. R., 18
 MacGillivray, (Mrs.) M. E., 32
 MacGregor, D. R., 330
 MacIntyre, T. M., 18
 Mack, A. R., 172
 Mack, R. N., 342
 MacKay, D. C., 294
 MacKinnon, J. P., 8
 MacLean, A. A., 31, 32
 MacLean, A. J., 171
 MacLellan, C. R., 17
 MacLeod, J. A., 7
 MacLeod, L. B., 7
 MacMillan, K. A., 65
 MacNaughton, W. N., 207
 MacNeil, J. D., 329
 MacPhee, A. W., 17
 Madhosingh, C., 147
 Madsen, H. F., 329
 Magee, A. I., ix
 Mahadevan, S., 118
 Mailloux, M., 66
 Malloch, D. W., 131
 Mallough, E. D., 243
 Marks, C. F., 109
 Marriage, P. B., 81
 Marshall, W. D., 147
 Martel, P., 65
 Martel, Y., 54
 Martens, J. W., 223
 Martin, A. H., 285
 Martin, J. E. H., 129
 Martin, R. W., 93
 Masner, L., 131
 Mason, J. L., 330
 Mason, W., 45
 Mason, W. R. M., 131
 Mathur, S. P., 171
 Matsuda, R., 130
 Matsumoto, T., 341
 Matthews, G. B., 117
 Maurer, A. R., 313
 Maw, M. G., 243
 McAlpine, J. F., 130
 McArthur, J. M., 329
 McBean, D. S., 265

- McBeath, D. K., 285
 McCartney, D. H., 235
 McClanahan, R. J., 81
 McDonald, S., 294
 McDonald, W. C., 223
 McDougall, J. I., 172
 McElgunn, J. D., 265
 McElroy, F. D., 341
 McGinnis, A. J., 109
 McGregor, D. I., 251
 McGuffin, W. C., 131
 McGugan, W. A., 161
 McIntosh, D. L., 330
 McIntyre, G. I., 243
 McIsaac, J. A., 7
 McIver, R. N., 244
 McKeague, J. A., 172
 McKeen, C. D., 82, viii
 McKenzie, A. R., 32
 McKenzie, H., 294
 McKenzie, J. S., 277
 McKenzie, R. I. H., 223
 McKillican, (Miss) M. E., 161
 McKinlay, K. S., 252
 McLaughlin, N. B., 294
 McLean, A., 319
 McLeod, D. G. R., 183
 McLintock, J. J. R., 252
 McMahan, H., 252
 McMechan, A. D., 329
 McMullen, R. D., 329
 McNeill, J., 129
 McPherson, (Miss) A. E., 251
 Meheriuk, M., 330
 Mellor, (Miss) F. C., 342
 Menzies, D. R., 109
 Merritt, E. S., 119, viii
 Metcalfe, D. R., 223
 Michalyna, W., 172
 Michaud, R., 53
 Migicovsky, B. B., v
 Miles, J. R. W., 184
 Miller, C. D. F., 82, viii
 Miller, D. M., 184
 Miller, R. W., 147
 Miller, S. R., 94
 Milliron, H. E., 131
 Mills, J. T., 223
 Milne, (Miss) H. K., 251
 Miltimore, J. E., 313, 319
 Minshall, W. H., 183
 Misener, G. C., 32
 Miska, J. P., 293
 Mitchell, K. B., 191
 Modler, H. W., 161
 Moen, H., 266
 Mohr, W. P., 94
 Molberg, E. S., 243
 Molnar, J., 199
 Monteith, L. G., 94
 Montgomery, G. F., 191
 Moore, R. J., 129
 Morgan, C. V. G., 329
 Morita, H., 171
 Morley, H. V., viii
 Morris, R. F., 1
 Morris, T. J., 342
 Morrison, J. W., viii
 Morse, (Ms.) P. M., 203
 Mortimore, C. G., 81
 Mosquin, T., 131
 Mountain, W. B., v
 Mukerji, M. K., 95
 Mukhoty, H. M., 119
 Mulligan, G. A., 129
 Mulvey, R. H., 130
 Munro, D. C., 8
 Munroe, E. G., 131
 Murray, (Miss) B. E., 94
 Murray, W. J., 285
 Mutuura, A., 131
 Myhr, P. I., 265
 Nagai, J., 117
 Nagai, T., 183
 Nass, H. G., 7
 Nathan, (Mrs.) V., 183
 Neal, J. L., 295
 Neilson, W. T. A., 17
 Nelson, D. L., 277
 Nelson, G. A., 294
 Nelson, W. A., 295
 Newman, J. A., 285
 Neyroud, J. A., 174
 Nicholaichuk, W., 266
 Nicholson, J. W. G., 31
 Nielsen, J. J., 223
 Nishida, A., 286
 Northover, J., 109
 Nowland, J. L., 172
 Nunes, A. C., 161
 Nuttall, V. W., 82
 Nuttall, W. F., 235
 O'Brien, C. P., 117
 Oliver, A. L., 325
 Oliver, D. R., 129
 Oliver, K. D., 223
 Olthof, T. H. A., 109
 Oosterveld, M., 295
 Osgood, C. E., 224
 Osoro, M. O., 226
 Ouellet, C. E., 148
 Paliwal, Y. C., 148
 Pandeya, R. S., 75
 Pankiw, P., 277
 Paquin, R., 53
 Paradis, R. O., 65
 Parchomchuk, P., 329
 Parent, B., 65
 Parmelee, J. A., 131
 Parups, E. V., 199
 Paton, D., 161
 Paulhus, D. L., 203
 Pawlowski, S. H., 251

Peck, O., 131
 Pekkala, D. H., 342
 Pelletier, G., 45
 Pelletier, G., 53
 Pelton, W. L., 266
 Penney, B. G., 1
 Pepin, H. S., 342
 Perron, D. R., 203
 Pesant, A., 45
 Peschken, D. P., 243
 Peters, H. F., 117
 Peters, T. W., 173
 Peterson, B. V., 130
 Peterson, D. G., v, ix
 Peterson, E. A., 147
 Petrie, G. A., 252
 Pettapiece, W. W., 173
 Pézerat, H., 174
 Phillips, J. H. H., 109
 Phillips, P. A., 191
 Pickford, R., 252
 Piening, L. J., 285
 Pieuk, (Mrs.) K. C., 293
 Pigden, W. J., viii
 Piloski, A. P., 207
 Pirozynski, K. A., 131
 Pittman, U. J., 295
 Plessers, A. G., 93
 Plews, K. W., 235
 Poapst, P. A., 18
 Pomeroy, M. K., 148
 Pond, D. D., 31, 32
 Porritt, S. W., 330
 Porteous, R., 171
 Potter, J. W., 109
 Poushinsky, G. P., 203
 Pree, D. J., 17
 Presant, E. W., 172
 Price, K. R., 203
 Pringle, R. B., 147
 Pringle, W. L., 277
 Proudfoot, F. G., 18
 Proudfoot, K. G., 1
 Proverbs, M. D., 329
 Puri, S., 203
 Putnam, L. G., 252
 Putt, E. D., 215

 Quamme, H. A., 82
 Quinn, J. R., 162

 Ragab, M. T. H., 18
 Ragetli, H. W. J., 342
 Rahnefeld, G. W., 207
 Raine, J., 341
 Rajhathy, T., 93
 Rakow, G., 253
 Randall, C. J., 161
 Rayment, A. F., 1
 Read, D. C., 8
 Read, D. W. L., 265
 Redmond, J. A., 207
 Reid, W. S., 191

Reimer, (Mrs.) E. H., 285
 Reiser, B., 203
 Reyes, A. A., 109
 Ricard, P., 65
 Rice, W. A., 277
 Rich, G. B., 319
 Richard, C., 54
 Richards, W. R., 130
 Richardson, L. T., 184
 Rioux, R., 54
 Rivard, I., 65
 Roberts, D. W. A., 294
 Roberts, J. G., 173
 Robertson, G. W., 266
 Robertson, H. A., 118
 Robertson, J. A., 235
 Robertson, R. H., 295
 Robertson, R. W., 94
 Robinson, J. R., 183
 RoCHAT, E., 53
 Rohringer, R., 223
 Romanow, W., 223, 224
 Ronald, W. G., 215
 Rosa, N., 75
 Rosher, R. M., 330
 Roslycky, E. B., 183
 Ross, G. J., 171
 Ross, R. G., 18
 Ross, W. B., 109
 Rostad, H. P. W., 173
 Rouatt, J. W., 147
 Rousselle, G. L., 65
 Roy, G., 45
 Roy, R., 129
 Russell, D. G., 8
 Russell, G. C., 81
 Russell, K. D., 293
 Russell, W. A., 215
 Ryan, J. E., ix

 Saha, J. G., 147, 252
 Sahasrabudhe, M. R., 161, 162
 Saidak, W. J., 82, viii
 Saini, G. R., 32
 St-Pierre, C. A., 53
 St-Pierre, J. C., 53
 Salam, M. A., 253
 Salkeld, (Miss) E. H., 130
 Salmon, R. E., 265
 Samborski, D. J., 223
 Sampson, D. R., 93
 Sanderson, J. B., 7
 Sanford, K. H., 17
 Santerre, J., 54
 Sarkar, N. K., 118
 Sarkar, S. K., 253, 331
 Sauer, F. D., 118
 Savile, D. B. O., 131
 Schmid, F., 131
 Schneider, E. F., 147
 Schnitzer, M., 171
 Schoening, C. G., 293
 Schori, A., 1

Schroder, D. J., 17
 Scott, W. A., 81
 Seaman, W. L., 93
 Sévigny, L. M., 45
 Sexsmith, J. J., 294
 Sharma, H. R., 32
 Shearer, D. A., 148
 Sheidow, N. W., 75
 Shemanchuk, J. A., 295
 Shewell, G. E., 130
 Shields, J. A., 172
 Shih, C. S., 203
 Shoemaker, R. A., 131
 Sholborg, P. L., 225
 Sibbald, I. R., 118
 Siddiqui, I. R., 161
 Siemens, B., 278
 Siminovitch, D., 148
 Simpson, C. M., 109
 Simpson, W. G., 17
 Sims, R. P. A., 162, viii
 Singh, J., 149
 Singh, R. P., 32
 Singh, R. P., 296
 Singh, S. S., 171
 Sinha, R. C., 148
 Sinha, R. N., 224
 Sinha, R. P., 161
 Sirois, J. C., 148
 Slen, S. B., 293
 Sly, W. K., 148
 Slykhuis, J. T., 93
 Small, E., 129
 Smeltzer, G. G., 18
 Smetana, A., 130
 Smid, A. E., 207
 Smith, A. D., 295
 Smith, A. E., 243
 Smith, B. C., 81
 Smith, D. S., 295
 Smith, I., 132
 Smith, J. D., 252
 Smith, L. B., 224
 Smith, R. E., 172
 Smoliak, S., 294
 Sneddon, J. I., 173, 341
 Sommerfeldt, T. G., 295
 Sonmor, L. G., 251
 Sonntag, B. H., 293
 Sowden, F. J., 171
 Spangelo, L. P. S., 277
 Specht, H. B., 17
 Spencer, E. Y., 183
 Spratt, E. D., 207
 Spurr, G. T., 117, 203
 Stace-Smith, R., 342
 Stanfield, B., 7
 Staple, W. J., 171
 Stark, R., 17
 Starratt, A. N., 183
 Stauffer, M. D., 215
 Sterling, J. D. E., 7
 Stevenson, A. B., 109
 Stevenson, D. S., 330
 Stevenson, I. L., 293
 Stewart, D. K. R., 18
 Stewart, D. W., 266
 Stewart, W. W. A., 252
 Stoessl, A., 184
 Stonehouse, H. B., 173
 Stothart, J. G., 289
 Strain, J. H., 207
 Stringam, G. R., 251
 Struble, D. L., 294
 Sudom, M. D., 1, 172
 Sussmann, (Mrs.) N. B., 129
 Sutherland, (Miss) K. M., 81
 Suzuki, M., 7
 Svec, H. H., 184
 Svejda, (Miss) F. J., 199
 Swailles, G. E., 294
 Swierstra, E. E., 207
 Symko, S., 93
 Tai, G. C. C., 32
 Tarn, T. R., 32
 Tarnocai, C., 172
 Tauthong, S., 225
 Taylor, D. K., 313
 Taylor, M. E., 251
 Tekauz, A., 224
 Teskey, H. J., 130
 Thomas, P. L., 224
 Thompson, B. K., 203
 Thompson, J. L., 266
 Thompson, L. S., 7
 Thorlacius, S. O., 235
 Thorn, G. D., 184
 Timbers, G. E., 191
 Tingle, E. M., 17
 Tingle, J. N., 278
 Tinline, R. D., 252
 Tolman, J. H., 184
 Tomlin, A. D., 184
 Toms, H. N. W., 342
 Tonks, N. V., 325
 Topp, G. C., 171
 Torfason, W. E., 294
 Towill, W. B., 95
 Townley-Smith, T. F., 265
 Townsend, L. R., 18
 Townshend, J. L., 109
 Tremaine, J. H., 342
 Trottier, R., 109
 Tsang, C. P. W., 118
 Tsang, (Ms.) J., 203
 Tu, C. M., 184
 Turnbull, J. E., 191
 Turner, R. C., 171
 Turnock, W. J., 224
 Ukrainetz, H., 251
 Valentine, K., 173, 341
 Vandenheuvel, F. A., 118
 Vanderlee, J., 224

- van Ryswyk, A. L., 319
 van Schaik, J. C., 295
 van Ysselstein, M., 183
 Vardanis, A., 183
 Venne, P., 53
 Verma, G. P., 266
 Vesely, J. A. P., 293
 Vickery, L. S., 75
 Vijayalakshmi, K., 226
 Virmani, S. M., 296
 Vockeroth, J. R., 130
 Voisey, P. W., 191
 Voldeng, H. D., 94
 von Stryk, F. G., 81
 Vrain, T. C., 65

 Waddington, J., 235
 Waldern, D. E., 313, 319
 Walker, D. R., 285
 Walker, E. K., 75
 Walker, P. H., 295
 Walkof, C., 215
 Wall, G. J., 172
 Wallen, V. R., 93
 Walley, G. S., 131
 Walsh, (Mrs.) D. S., 118
 Wang, C., 172
 Ward, E. W. B., 184
 Ward G. M., 81
 Warder, F. G., 266
 Ware, D., viii
 Warren, F. S., 94
 Wasik, R. J., 161
 Watson, M. C., 75
 Watt, W., 173
 Watters, F. L., 224
 Wauthy, J. M., 94
 Weaver, G. M., 31
 Webber, M. D., 171
 Webster, D. H., 18
 Weintraub, J., 295
 Weintraub, M., 341
 Weiss, G. M., 286
 Wells, S. A., 294
 Welsh, M. F., 330
 Wensley, R. N., 82
 Weresub, (Miss) L. K., 131

 Westcott, N. D., 252
 Westdal, P. H., 224
 Whelan, E. D. P., 215
 White, F. H., 75
 White, G. A., 184
 White, R. P., 7
 Whitfield, D. H., 295
 Whitten, F. J., 31
 Wilkes, A., 131
 Wilkinson, A. T. S., 341
 Wilkinson, P. R., 296
 Willemot, C., 53
 Williams, C. J., 203
 Williams, G. D. V., 148
 Williams, I. H., 341
 Williams, R. J., 54
 Willis, C. B., 7
 Wilner, J., 199
 Wilson, D. B., 294
 Wilson, G., 172
 Winter, K. A., 8
 Wolfe, R. I., 207
 Wood, D. F., 330
 Wood, D. M., 130
 Wood, G. W., 32
 Wood, P. J., 162
 Wressell, H. B., 82
 Wright, J. R., 17
 Wright, L. M., 265
 Wright, N. S., 341
 Wu, (Miss) L.-Y., 130
 Wylie, H. G., 224

 Yang, A. F., 342
 Yates, A. R., 161
 Yoo, J. Y., 253
 Yoshimoto, C. M., 131
 Young, D. A., 31
 Young, J. C., 147

 Zarkadas, C. G., 162
 Zawalsky, M., 119
 Zentner, R. P. J., 295
 Zilkey, B. F., 75
 Zimmer, R. C., 215
 Zizka, J., 54
 Zuk, P., 341

SUBJECT INDEX

- α -Tocopherol 126
- Acclimation 280
- Activité oestrale 48
- Agricultural engineering 332
- Agricultural watersheds 39
- Agrometeorology 155
- Alfalfa breeding and varieties (*see also* luzerne)
101, 211, 236, 255, 269
- Alfalfa chemistry 255
- Alfalfa diseases 257
- Alfalfa management 21, 33, 236, 280, 322, 333
- Alfalfa seed production 236, 282, 300
- Altai wild ryegrass 270
- Alternaria 23
- Aluminum 10
- Amino acids 157, 167, 267
- Ammonia 124
- Animal waste management 193
- Annuals 200
- Aphids 10, 36, 37, 110, 299, 346
- Apiculture 279
- Apple diseases 23, 335, 336
- Apple harvesting 39
- Apple maggots 24
- Apple moth 24
- Apple scabs 112
- Apple stocks 338
- Apples 20, 104, 336
- Apricots 88
- Aquatic insects 137
- Aquatic weeds 303
- Arachnida 137
- Arboretum 221
- Arboviruses 260
- Armyworms 257
- Ascomycetes 140
- Asparagus 86
- Aster yellows 155, 344
- Asulam 211
- Avoine (*V. aussi* oats) 57, 61
- Baby carrots 86
- Bacillus thuringiensis* 185
- Bacteriophage 163
- Barley (*see also* orge) 97, 211, 227, 239, 279,
289, 291
- Barley breeding 9, 97, 302
- Barley genetics 98, 302
- Barley production 212
- Barley viruses 10, 58, 155, 229
- Barley yellow dwarf virus 10, 58, 155
- Basidiomycetes 140
- Bean yellow mosaic 99
- Beans 86
- Beef cattle (*see also* meat, steers, feedlot) 208,
240, 287, 297, 320
- Beef housing 123
- Beef muscle 167, 288
- Beef nutrition 14, 33, 123, 238, 239, 240, 281,
297
- Beef production 123, 208
- Bees 236, 259, 279, 282, 300
- Benomyl 88, 113, 185, 187
- Bertha armyworm 257
- Bioassays 77, 205
- Biological control 245, 333
- Biological oxidation 151
- Bird control 39
- Birdsfoot trefoil 11
- Biting flies 138, 306
- Black flies 306
- Blight, potato 12, 37, 99
- Bloat 298, 233
- Blood metabolites 298
- Blueberries 19
- Boars 287
- Boron compounds 105, 168, 316
- Boron toxicity 10
- Bouvillons croisés (*voir aussi* crossbreeding,
steers) 47
- Brassica breeding 4
- Brebis (*voir aussi* ewes) 48
- Broad-leaved meadowsweet 19
- Broiler breeder stock 122
- Broilers 314
- Bromegrass 100, 101, 210, 255
- Bromegrass fertilizer 210
- Brown line decline virus 335
- Brussels sprouts 13, 316
- Buckwheat 167, 217
- Burley tobacco 84
- Cabbage looper 86
- Cabbage maggots 3, 86, 299
- Cabbages 86, 303
- Cabbageworm 86
- Calcium deficiencies 87
- Cannabis 136
- Carbohydrate crops (*see also specific crop*) 218
- Carboxin 187
- Carcass quality 167, 208, 269
- Carottes (*V. aussi* carrots) 70
- Carrot insects 111
- Carrots 3, 20
- Cartography 178
- Cattle diseases 321
- Cauliflowers 13
- Celery 20
- Cell biology 151
- Cell components 151
- Cereal crops (*see also specific cereal*) 96, 167,
211, 267, 279, 288
- Cereal digestibility 122
- Cereal diseases 10, 84, 228, 301
- Cereal insects 10
- Cereal management 9
- Cereal physiology and nutrition 9, 21
- Cereal protein 122
- Cereal silage 34, 105
- Céréales (*V. aussi* cereals) 57, 59, 61
- Cereals (*see also* wheat, barley, oats, corn, rye)
9, 255, 301

- Charançon de la carotte (*V. aussi* carrot insects) 70
- Charançon de la prune 67
- Charbon de l'oignon (*V. aussi* smuts) 70
- Cheese flavor 163
- Chemical control 306, 307, 333, 336, 345, 347
- Chemistry, analytical 156, 157
- Chemistry, environmental 152
- Chernozemic soils 291
- Cherries 335
- Cherry diseases 335
- Cherry rasp leaf virus 335
- Chickweed 290
- Chlamydospores 150
- Chloroneb 187
- Choux (*V. aussi* cabbages) 71
- Citrus juices 168
- Clover phyllody 155
- Clubroot 4, 13
- Cochenille virgule 67
- Codling moth 24, 332, 333
- Cold acclimation 280
- Cold hardiness 89
- Cold tolerance 268
- Coleoptera 137
- Colorado potato beetle 38
- Common yarrow 327
- Companion crops 237
- Conservation, plantes fourragères (*V. aussi* forage preservation) 61
- Copper 281, 320
- Corn (*see also* maïs) 101, 102, 217
- Corn breeding 84, 101, 217, 303
- Corn management 12, 212
- Corn production 212
- Corn silage 123, 302
- Cranberries 19, 23, 25
- Crop losses 98
- Crop rotations 239
- Crossbreeding 121, 208, 287, 314
- Crown gall 90
- Crown rot 23, 335
- Crown rust (*see also* rusts) 228
- Cucumber breeding 87
- Cucumbers 86, 87, 220
- Cutworms (*see also* vers gris) 23, 79, 299
- Cytogenetics 99, 226, 302
- 2,4-D 248
- DDT translocation 77
- Dairy cattle breeding 120, 314
- Dairy cattle nutrition 33, 124, 125
- Damping off 78, 79
- Dikar 104
- Dikeland soils 22
- Dinitroaniline 211
- Diptera 138
- Diseases (*see* plant diseases)
- Drageons du tabac 43
- Drainage 2, 59, 304, 305
- Durum wheat 167, 227, 267
- Ecology 110
- Ecosystem assessment 155
- Egg packaging 26
- Eggshell formation 122
- Electron microscope 157
- Electrophoresis 99
- Endogenous processes 154
- Endosulfan 24
- Ensilage (*V. aussi* silage) 49
- Entomology (*see also* insects) 229, 257, 299, 306, 320, 333, 346
- Environment 271, 280
- Environmental quality 188
- Enzymes 305
- Equipment, farm 272
- Equipment, research 272
- Ergot 99, 301
- Essential oil crops (*see also* specific crops) 219
- Estrogens 122, 123
- Estrus, sows 209
- Ethephon 326
- European corn borer 87
- European red mite 110, 111
- Euxoa 138
- Ewes (*see also* brebis) 121, 124
- Experimental design 206
- Experimental taxonomy 138
- Eyespot 280
- Fababeans 9, 22, 33, 103, 105, 193, 239, 240
- Farm building 193
- Faunistics 139
- Fertilization 59, 84, 105
- Fertilizers 2, 10, 12, 210, 211, 291, 304, 321, 326
- Fetal fluids 209
- Field crops (*see also* tobacco, peas, buckwheat, beets, beans, corn) 84, 85, 86, 167, 217
- Finishing steers 238
- Finnish Ayrshires 120
- Fire blight 90, 335
- Flavonol glucosides 85
- Flax 211, 218
- Flea beetles 258
- Flétrissure (*V. aussi* blight, potato) 60
- Flora 271
- Foliage color 202
- Food technology 26, 205, 334
- Forage (*see specific legume or grass*)
- Forage breeding 269, 281
- Forage cereals 255, 289
- Forage crops 101, 210
- Forage diseases 2, 257, 301
- Forage handling 192
- Forage harvesting 3, 193, 237
- Forage insects 259
- Forage management 105
- Forage mixtures (*see also* mélanges à foin) 210, 302
- Forage nutrition 11
- Forage preservation (*see also* conservation, plantes fourragères) 3
- Forage production 236
- Forage utilization 236, 238

Forage viruses 84
 Forage yield 105, 210, 247, 270, 321
 Formaldehyde treatment 34
 Fraisiers (*V. aussi* strawberries) 60, 61, 69
 French fries 26
 Frost hardening 153
 Frost heaving 33
 Fruit (*see also specific fruit*) 39, 60, 104
 Fruit blemishes 113
 Fruit flies 333
 Fruit ripening 337
 Fruit softening 337
 Fruit viruses 112
 Fulvic acid 175
 Fumure (*V. aussi* manure, fertilizers) 59
 Fungicides 187
 Fusarium 150, 151, 326

 Gene transfer 77
 Genetics 77, 226
 Génisses croisées 47
 Gilts 122
 Grasses 101, 136, 192, 254, 270, 281
 Grasshoppers 231, 258, 299
 Greenhouse whitefly 327
 Grit 26
 Growth regulators 154, 188, 200, 316, 337
 Grubs 307

 Hardiness 153
 Harvesting 237
 Hay drying 237
 Hay storing 237
 Hay yield 255
 Helminthosporium 151
 Hemagglutination 165
 Hemiptera 137
 Hemp-nettle 10
 Hens 314
 Herbicide residues 3, 84, 89, 248
 Herbicides 10, 153, 188, 211, 212, 218, 236, 246, 248, 289, 290, 315
 Hespérie européenne 55
 Highbush blueberry 19
 Honey bees 100, 101
 Horizontal silos 302
 Hormones 122, 123, 209
 Horticultural crops (*see also fruits, vegetables, ornamentals*) 12, 86, 103, 282, 289, 303, 326
 Humic substances 175
 Humus extracts 305
 Hymenomycetes 140
 Hymenoptera 139

 Insect population dynamics 100
 Insect sampling 231
 Insecticides (*see also pesticides*) 13, 152, 153, 185, 186, 231, 300
 Insects (*see also specific orders, insecticides, entomology*) 10, 23, 24, 39, 84, 110, 231, 259, 299

Institutional foods 334
 Integrated control 110
 Intermediate wheatgrass 270
 Irrigation 256, 272, 304, 332, 338

 Lactation 46
 Lactating cows 124
 Lait de substitution (*V. aussi* milk replacers) 46
 Lamb rearing 124, 125
 Lambing 121
 Land use 177
 Laying hens 314
 Leaf blights 85
 Leaf diseases 228
 Leaf position 77
 Leafcutter bees 236, 259, 282, 300
 Leafy spurge 246
 Leatherjackets 347
 Legumes 255, 270
 Légumes (*see also vegetables*) 61
 Lepidoptera 139
 Lettuce 3, 20, 315
 Leucostoma lesions 112
 Lime pelleting 12
 Limestone 22
 Linoleic acid test 254
 Linuron 176
 Livestock feeds 33
 Lowbush blueberry 19
 Luzerne (*V. aussi* alfalfa) 49, 55, 57

 Magnesium 10
 Maïs (*V. aussi* corn) 69
 Maleic hydrazide 152
 Malherbologie 70
 Manure (*see also fertilizers*) 126
 Marek's disease 120, 210
 Mauvaises herbes, répression (*V. aussi* weed control) 43
 Meat 167, 288
 Meat products 167
 Mélanges à foin (*V. aussi* forage mixtures) 60
 Membrane lipids 153
 Membranes 151
 Mercury contamination 201
 Microbiology (*see also specific microflora*) 150, 298
 Mil (*V. aussi* timothy) 55, 60
 Milk coagulation 163
 Milk gels 164
 Milk products 164, 165
 Milk replacers (*see also lait de substitution*) 35
 Mineral soils 2, 20
 Mini-carottes (*V. aussi* baby carrots) 70
 Miseroxin 321
 Mites 24, 100, 110, 333
 Mitochondria 154
 Monogastric nutrition 122
 Mosquitoes (*see also biting flies*) 259, 306
 Mouche de la pomme (*V. aussi* apple maggots) 68
 Mouse research 121
 Mummy berry 345

- Muscular dystrophy 126
- Mustard 165, 254
- Mycology 140

- Nematicides (*see also* insecticides) 112
- Nematodes 4, 10, 11, 14, 56, 88, 89, 111, 137, 200, 345
- Nitrogen (*see also* fertilizers) 76, 271, 291
- Nitrogen fixation 282
- Nitrogen movement 85
- Nodulation 282
- Noxious plants (*see also* weeds) 136
- Numerical taxonomy 206
- Nursery stock 201
- Nutrient deficiencies 291

- Oat breeding and genetics 9, 97, 227
- Oat diseases 97, 228, 229
- Oats (*see also* avoine) 97, 99, 136, 167, 239, 288, 289
- Oignons (*V. aussi* onions) 70
- Oilseed chemistry 165, 166
- Oilseed diseases 257
- Oilseed processing 166
- Oilseeds (*see also* rapeseed, mustard, soybeans, sunflowers) 165, 211, 218, 254
- Onions (*see also* oignons) 168
- Orchardgrass 101
- Organochlorine insecticides 153, 188
- Organophosphorus insecticides 109, 152, 188
- Orge (*V. aussi* barley) 58
- Ornamental plants 20, 200, 201, 220, 315

- Parasites 138, 232, 307
- Pastures 12, 238, 271, 281
- Pea diseases 217
- Pea tenderometer 103
- Peach X-disease 112
- Peaches 88
- Pears (*see also* poires) 25, 90
- Peas 22, 33, 98, 103, 217, 218
- Peat soil 2, 3, 20, 338
- Pelleting 12, 269
- Pepper diseases 112, 113
- Pepper viruses 112
- Peppers 112, 113
- Pepsin 163
- Pesticide application 109, 260
- Pesticide chemistry 260
- Pesticide metabolism 109, 126, 260
- Pesticide residues 24, 126, 157, 186, 188, 248, 300, 334, 347
- Pesticides (*see also* fungicides, herbicides, insecticides) 79, 109, 152
- Petits fruits (*V. aussi* small fruits) 61, 69
- Phenolic compounds 165
- Pheromones 67, 152, 185
- Phosphorus 268, 271
- Phycomycetes 140
- Physiological maturity 77
- Pig rations 240
- Pin nematode 111
- Plant breeding (*see also specific plant*) 77, 288
- Plant diseases (*see* nematodes; fungicides; blight, potato; rusts)
- Plant introductions 103, 212
- Plant nutrition (*see* fertilizers)
- Plant pests 185, 231
- Plant propagation 221, 316
- Plantes fourragères 55, 57, 60
- Plasma germinatif 42
- Poires (*V. aussi* pears) 60, 68
- Pollution (*see also* environment) 125, 261, 299
- Polyaromatic hydrocarbons 176
- Pommerais 68
- Pommes (*V. aussi* apples) 60, 68
- Pommes de terre (*V. aussi* potatoes) 60
- Pomology 336
- Pork muscle 209
- Potassium 104, 316
- Potato breeding 3, 35, 103
- Potato diseases 12, 301, 345
- Potato insects 38, 299
- Potato nutrition 12
- Potato resistance 36, 37
- Potato viruses 13, 36
- Potato yield 36
- Potatoes 25, 34, 98, 220, 281, 304
- Poultry 120, 210, 298, 314
- Poultry breeding 120
- Poultry management 26
- Poultry nutrition 122, 210
- Poultry rearing 314
- Povertyweed 247
- Predators 138
- Proctolin 185
- Productions végétales 49
- Progesterone 122, 123
- Protein crops (*see also specific crop*) 218
- Prunes 60, 68

- Quack grass 290
- Quality measurements 194

- Rain gauges 280
- Rape insects 299
- Rape residues 300
- Rapeseed 35, 165, 239, 254, 289, 291
- Rapeseed insects 257, 299
- Rapeseed meal 34
- Rapeseed oil 35, 125
- Rapeseed protein 35
- Rapeseed weed 290
- Raspberries 20, 280, 315
- Raspberry breeding 315
- Raspberry viruses 315
- Récolte, plantes fourragères (*V. aussi* forage harvesting) 61
- Red clover 282, 289
- Red mite 24
- Reed canarygrass 281, 321
- Regression analysis 204
- Remote sensing 98
- Reproductive physiology 122
- Residue chemistry 347
- Rhizobium 56

- Roasters 314
- Rocky mountain wood tick 320
- Root maggot 79, 347
- Root rot (*see also* fusarium) 78, 85, 151, 256, 280, 289, 291
- Root-knot nematode 111
- Rootstocks 88, 89
- Rumen culture 124
- Ruminant nutrition 123
- Ruminants 314
- Russian wild ryegrass 269
- Rust resistance 228
- Rusts 140, 227, 228
- Rye 14

- Sainfoin 302
- Salt intake 298
- Sandy soils 85
- Scabs 112
- Scions 90
- Séchage du tabac (*V. aussi* tobacco drying) 42
- Seed culm 271
- Seed midge 255
- Seed treatments 306
- Seed yield 249
- Selenium 126, 152, 320
- Septoria 58
- Sewage sludge 175
- Sewage effluents 272
- Sex attractant (*see also* pheromones) 152, 333
- Sheep 27, 297
- Sheep breeding 121
- Sheep nutrition 124
- Sheep-laurel 19
- Silage 33, 123, 237, 302
- Siphonaptera 137
- Skim milk 165
- Small fruits (*see also* petits fruits) 315, 345
- Smoke characteristics 78
- Smuts 140, 228
- Snowfall measurements 280
- Soil acidity 282
- Soil amendments 236
- Soil characterization 176, 348
- Soil chemistry 304
- Soil classification 176, 348
- Soil compaction 38
- Soil conservation 175
- Soil degradation 177
- Soil enzymes 305
- Soil erosion 39
- Soil fertility 76, 282, 304
- Soil genesis 176
- Soil inventory 176
- Soil management 175
- Soil mapping 176, 348
- Soil microbiology 282
- Soil moisture 156, 212, 236
- Soil pollution 176
- Soil resources 176
- Soil structure 305
- Soil surveys 177
- Soil temperature 156

- Sol organique 71
- Solonetzic soil 291
- Sorghum 212, 302
- Soybean flour 35
- Soybeans 89, 102, 211
- Spartan apples 336
- Special crops 103, 239
- Sperm output 209
- Spraying 38, 332
- Spring wheat 9, 305
- Spurriness 337
- Stalk rot 85
- Starter culture 163
- Statistical analysis 204, 205
- Statistical science 204
- Steers 208, 238
- Stem rust (*see also* rusts) 227, 228
- Sterol biosynthesis 150
- Sterols 140
- Storage 25, 26
- Storage pests 229
- Strawberries 20, 104, 315
- Strawberry green petal 155
- Sugar cane drying 193
- Sugarbeet insects 300
- Summerfallow 242
- Sunflowers 219, 268
- Surfactants 338
- Sweet corn 87, 220
- Swine breeding 209, 287
- Swine muscle 209
- Swine nutrition 122

- Tabac (*V. aussi* tobacco) 42, 43
- Tabanids 138
- Tall wheatgrass 302
- Tavelure du pommier (*V. aussi* apple scabs) 68
- Tenderometer 103
- Testosterone 209
- Tétranique rouge (*V. aussi* mites) 67
- Textural studies 316
- Tick paralysis 320
- Tile spacing 85
- Timber milkvetch poisoning 321
- Timothy (*see also* mil) 101, 281
- Tissue culture 200
- Toadflax 280
- Tobacco 14, 76
- Tobacco breeding 77, 78
- Tobacco curing 77
- Tobacco drying (*see also* séchage du tabac) 77
- Tobacco harvesting 77, 193
- Tolérance au froid (*V. aussi* cold tolerance) 57
- Tomates (*V. aussi* tomatoes) 71
- Tomato breeding 289
- Tomato cultivation 87
- Tomato insects 87
- Tomatoes (*see also* tomates) 25, 26, 87, 88, 98, 326
- Tortrix 346
- Toxicology 10, 113, 151, 185, 268, 307
- Trace elements (*see also specific elements*) 126, 281

- Transformations azotées 71
- Transplanting 14
- Trash management 239
- Tree fruits 88
- Trichoptera 139
- Truies 48
- Turfgrass 201, 315
- Turkey nutrition 268
- Turnip-rutabaga hybrid 13
- Two-spotted mite 100

- Umbelliferous plants 113
- Urea 14, 34

- Veau 46, 47
- Vectors 346
- Vegetable mycology 113
- Vegetable nutrition 13
- Vegetable virology 112
- Vegetables (*see also* légumes) 87, 103, 220, 315
- Vêlage 47
- Vers gris (*V. aussi* cutworms) 44
- Verticillium wilt 37
- Vinyl phosphate insecticides 185
- Virology 112, 343, 345
- Virus infection physiology 343
- Virus multiplication 344
- Virus-free potatoes 345
- Vitamin E 320
- Vydate 345

- Warble flies 307
- Wart resistance 4
- Wasps 139
- Water filtration 332
- Water sampler 193
- Weaning 123
- Weed biological control 245
- Weed control (*see also* herbicides, growth regulators) 85, 86, 211, 212, 246, 280, 290, 303
- Weed taxonomy 136
- Weeds (*see also* noxious plants) 188, 248
- Weevils 100, 346
- Western wheatgrass 302
- Wheat 96, 226, 227, 239, 270, 301, 304
- Wheat breeding 96, 267, 301, 302
- Wheat hardening 301
- Wheat viruses 97, 154
- Wheat yield 271
- Whey 165
- Wild oats 239, 246, 290, 303
- Wine 334
- Winter wheat 239, 268
- Winterhardiness (*see also* cold hardiness) 153
- Winterkill 280, 333
- Wireworms 24, 38, 258, 347
- Woody plants 200, 327

- Yogurt 164

- Zinc micronutrients 104, 281

3 8072 00262472 4

3 9073 00208473 1

DATE DUE			
MAR 13 2010 JUN 15 2010			
GAYLORD			
			PRINTED IN U.S.A.

GAYLORD

PRINTED IN U.S.A.

